

# (L40P100) Striplet navigation & results

Jan 30, 2023

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<https://AMAGnm.com>

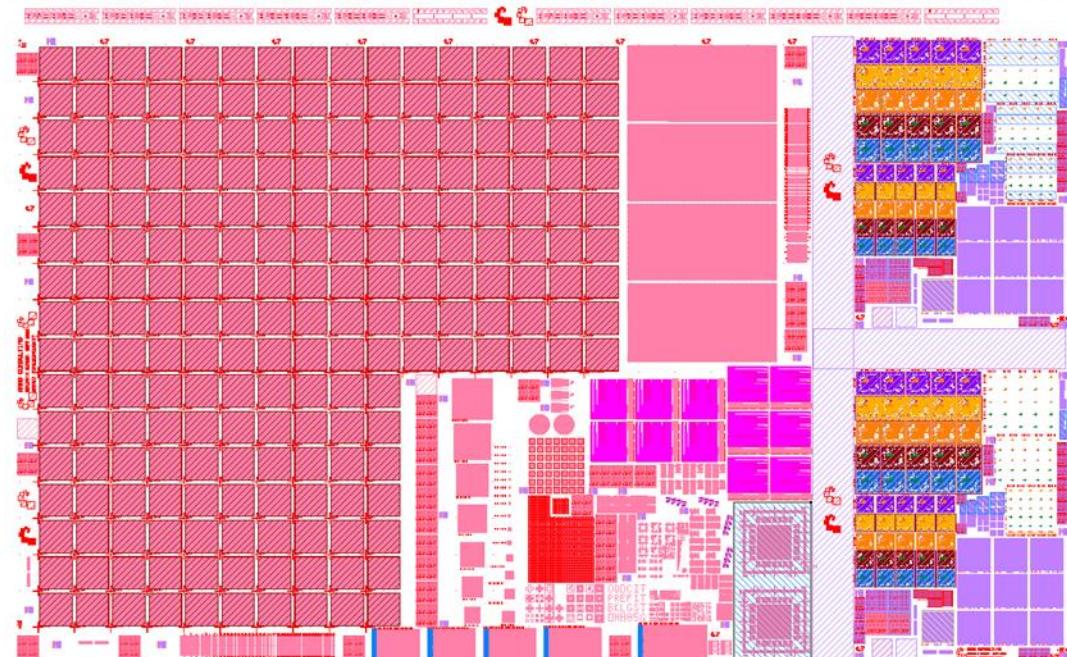
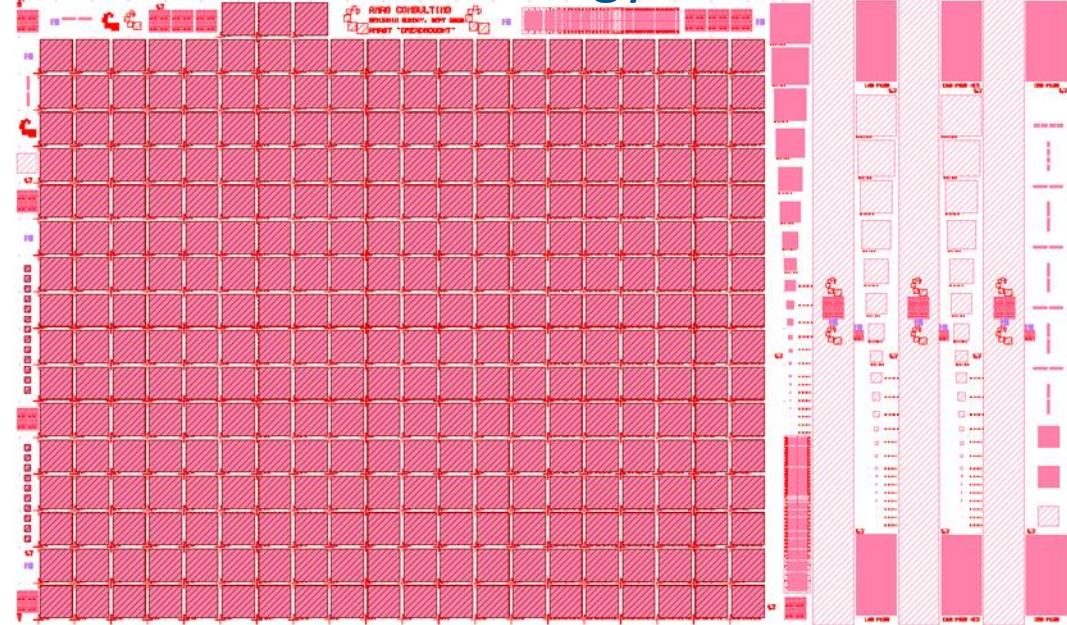
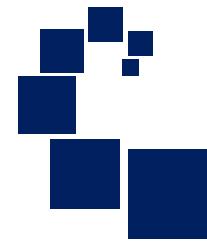
**Yvette Ball** (Wafer Production Manager)

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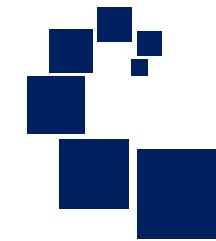
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# AMAG7 CD metrology modules

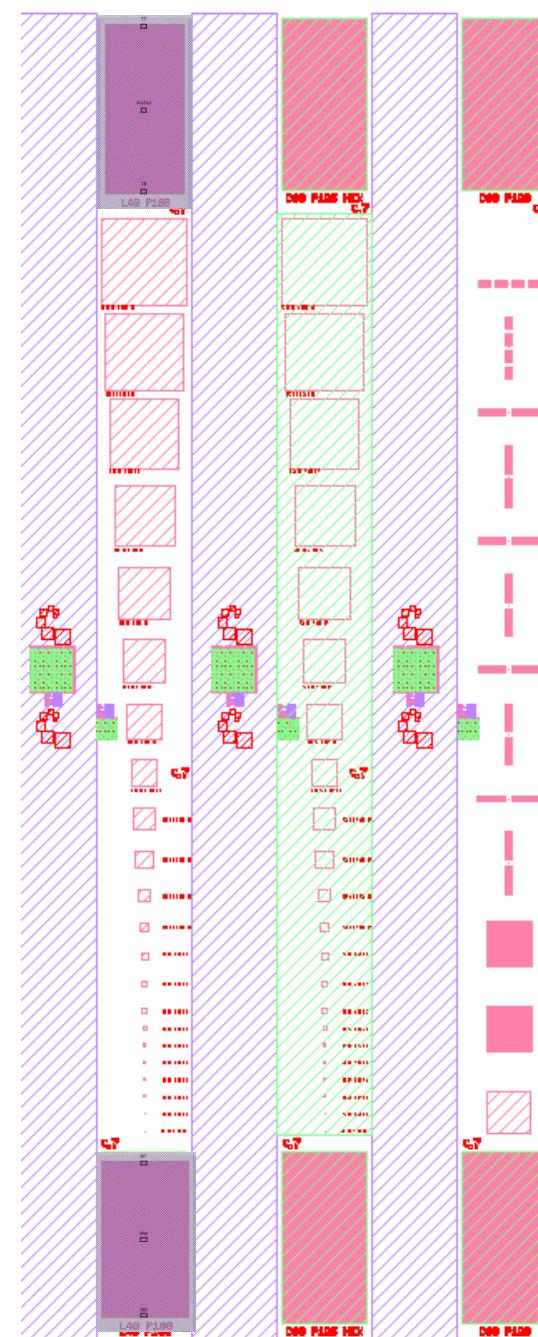


- Full die repeat size is 26.000mm x 33.000mm (exactly).
- All panes of AMAG7 are included. Full Field.

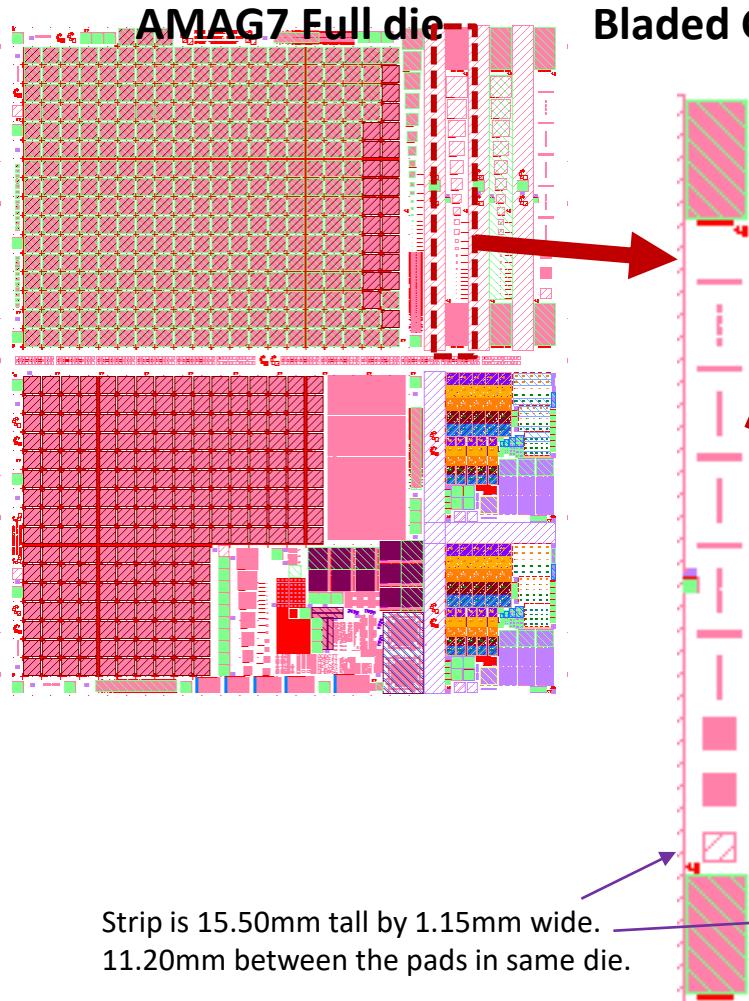
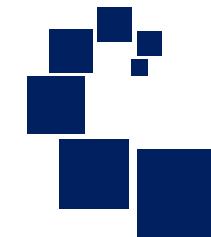
# AMAG7 User's Guide: GI-SAXS gratings



- Grazing Incidence CD-SAXS (GI-SAXS) has a much larger X-ray spot size than transmission T-SAXS, thus requires larger gratings. While there is not space on the reticle for all varieties of such marks, a few key ones are included: L40P100, C60P120 and C60P125HEX.
- The pads are 1x2mm in size, and top & bottom pads are perfectly colinear and 11.2mm apart.
- **Each target has its own chiplet separated by 1mm blading allowing for individual exposure of any one of the targets in a widely separated die pattern on a given wafer, which allows for each chip to have lots of space around it. See next page for diagram.**
- Care was taken to keep periodic content a few mm away from each of the grating pads. The content in between the pads is thus solid pads for film thickness measurement and simple scanner alignment marks.
- One DCP and BiB OVL mark is included with each pad near the middle of these chiplets, for process control.

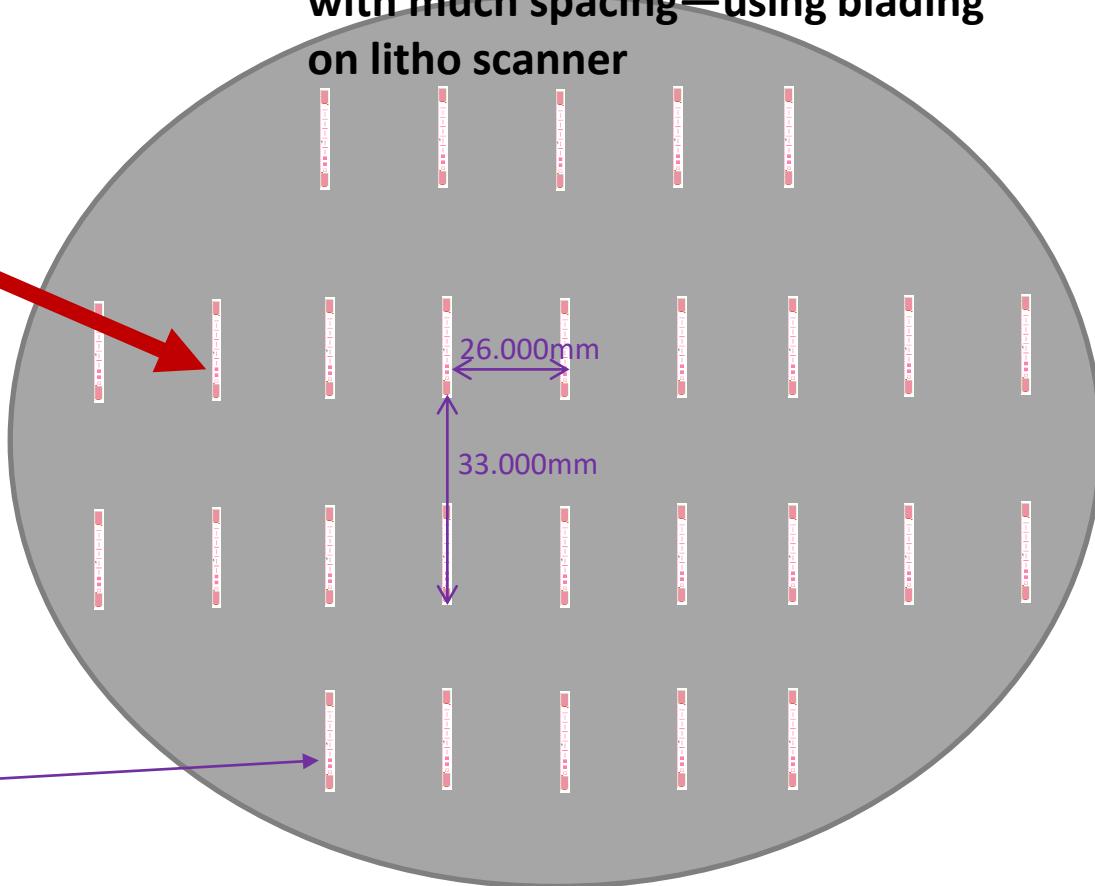


# Litho blading strategy utilized to define space in die pattern around GI-SAXS strips

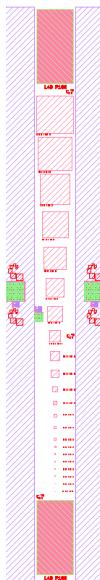
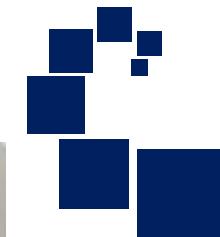


Bladed GISAXS strip

We pattern just one strip at a time with much spacing—using blading on litho scanner



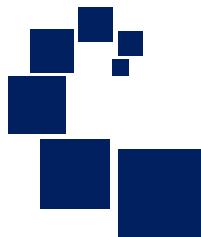
# AMAG7 Full Field Pattern for GI-SAXS LS Striplet



Photograph of Striplet pattern

Pattern	Wafer Type	x [um]	y [um]
1um DCP pattern rec cross	Striplet	7914	7564
AMAG7 L40P100 grating (anchor target-TM, 1x2mm pad)	Striplet	8083	15032
L40P100 grating (TT, 1x2mm pad)	Striplet	8315	16060
L40P100 grating (TB, 1x2mm pad)	Striplet	8303	14661
L40P100 grating (BT, 1x2mm pad)	Striplet	8315	2737
L40P100 grating (BM, 1x2mm pad)	Striplet	7969	1827
L40P100 grating (BB, 1x2mm pad)	Striplet	8316	1175
GDS center (cartesian coordinates)	no feature, bladed off	0	0

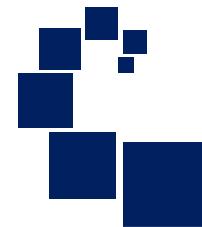
# Striptet wafer-level CD results



- This report shows the wafer-level averages and variation for each wafer of the first lot of the Line & Space product.
- Specific maps for each wafer including the average & 1sigma and SEM images of all-die of L40P100 and few sites of each of the secondary targets.
- CD values convey bottom CD of the lines.

Final CDSEM measurements (nm)									
			recipe = DNVM1FAMAG7ECDU1 (All Die)		recipe = DNVM1FAMAG7ECDU1 (11 die)				
Lot ID	Slot	Wfr ID	L40 P100 Top-Middle (XCH) All Die	L40 P100 (1-sigma)	L40 P10 Top-Top (NHL) 11 die	L40 P10 Top-Bottom (NVL) 11 die	L40 P10 Bottom-Top (IHL) 11 die	L40 P10 Bottom-Mid (IVL) 11 die	L40 P10 Bottom-Bottom (NHS) 11 die
2247EMEM001.000	1	46JZG073SJE5	44.19	0.16	44.7	44.3	44.8	44.5	45.1
2241EMEM001.000	2	46JZG072SJA3	44.39	0.24	44.8	44.3	45.0	44.6	45.2
2241EMEM001.002	2	46JJX083SJE3	43.85	0.25	44.3	43.9	44.6	44.2	45.0
2241EMEM001.002	3	46JJT004SJA5	44.29	0.25	44.7	44.4	45.0	44.6	45.2
Lot ID	All		44.29	0.20	44.8	44.3	44.9	44.6	45.2

# 46JGZ073SJE5 (2247EMEM001 slot 1) Reference Data



## L40P100 Anchor Target

Nov 2022

- All measurements in nm.
- Avg CD and 1sigma line-to-line variation for L40P100 anchor target for each die, reported for each die in wafer map format, and plotted to right.
- Average and 1sigma values are of 8 lines sampled at each site, from images on next page.
- CD values convey bottom CD of the lines.

Full Wafer Avg CD:	44.19	nm
Full wafer 1sigma CD:	1.28	nm
Die-to-Die 1sigma		
Avg:	0.16	nm
RMS:	0.19	nm
LWR Line (Avg):	2.44	nm
FOV:	1000	nm

Average of all individual die CD averages (8 targets/die).

Stddev of all die CD average of (8 targets/die), represents across wafer variation.

Feature-to-feature variation within grating.

Arithmetic average value of feature-to-feature variation.

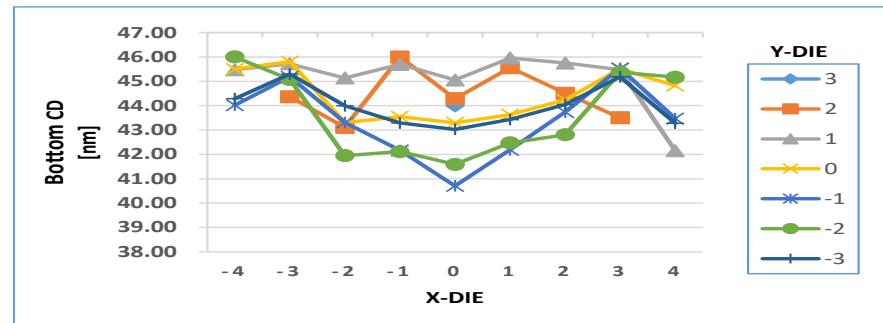
RMS average value of feature-to-feature variation.

Average of 3Sigma LWR (Linewidth)

Size of image (field-of-view).

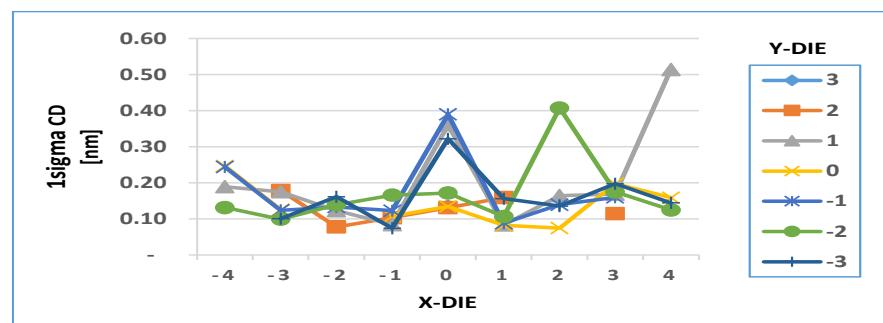
## L40P100 Anchor Target Avg CD (line)

	-4	-3	-2	-1	0	1	2	3	4
4					43.99				
3		44.37	43.11	46.00	44.29	45.56	44.51	43.51	
2	45.48	45.72	45.14	45.70	45.06	45.96	45.75	45.48	42.15
1	45.51	45.81	43.30	43.55	43.29	43.63	44.24	45.52	44.82
0	44.02	45.18	43.31	42.16	40.70	42.19	43.74	45.53	43.47
-1	46.01	45.07	41.95	42.12	41.59	42.47	42.81	45.37	45.17
-2	44.29	45.30	44.00	43.29	43.03	43.43	44.05	45.19	43.28
-3		45.51	44.10	44.61	43.54	44.81	43.89	44.95	



## L40P100 Anchor Target 1sigma CD

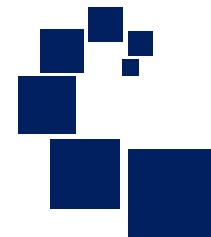
	-4	-3	-2	-1	0	1	2	3	4
4					0.14				
3		0.18	0.08	0.10	0.13	0.16		0.11	
2	0.19	0.18	0.12	0.08	0.36	0.08	0.16	0.17	0.51
1	0.25	0.13		0.11	0.13	0.08	0.07	0.20	0.16
0	0.24	0.12	0.13	0.12	0.39	0.09	0.14	0.16	
-1	0.13	0.10	0.14	0.17	0.17	0.11	0.41	0.17	0.12
-2	0.10	0.16	0.07		0.32	0.16	0.14	0.20	0.14
-3		0.12	0.18	0.11	0.19	0.17		0.14	



# 46JGZ073SJE5 (2247EMEM001 slot 1) Reference Data

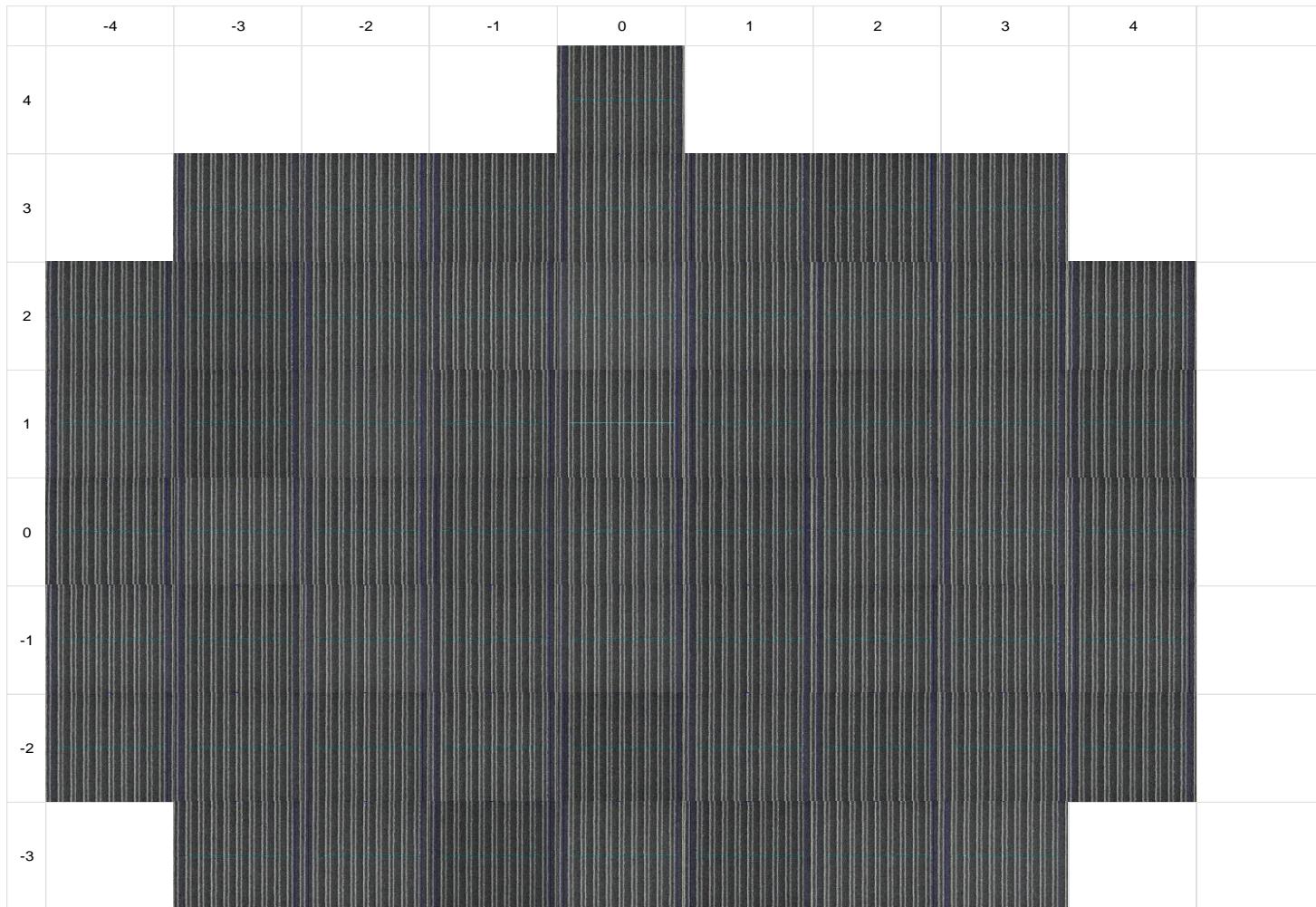
L40P100 Anchor Target

Nov 2022

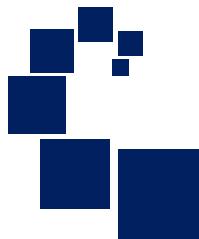


## L40P100 Anchor Target CD-SEM image wafer map

Full Wafer Avg CD:	44.19	nm
Full wafer 1sigma CD:	1.28	nm
Die-to-Die 1sigma		
Avg:	0.16	nm
RMS:	0.19	nm
LWR Line (Avg):	2.44	nm
FOV:	1000	nm



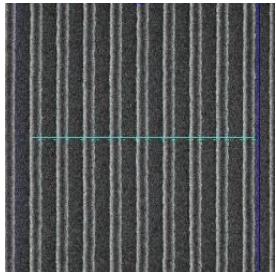
# 46JGZ073SJE5 (2247EMEM001 slot 1) Reference Data



Secondary Targets  
Nov 2022

## Anchor Target

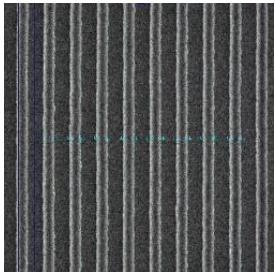
L40P100 (XLS\*)



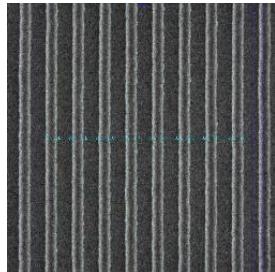
Full Wafer Avg CD:	44.19	nm
Full wafer 1sigma CD:	1.28	nm
Die-to-Die 1 sigma:		
Avg:	0.16	nm
RMS:	0.19	nm
LWR Line (Avg):	2.44	nm
FOV:	1000	nm

## Secondary Targets

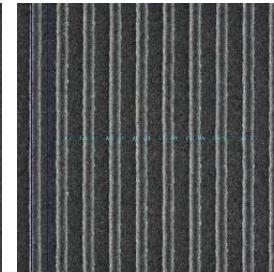
L40P100TT (NHL\*)



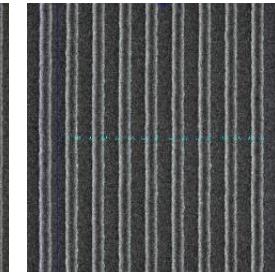
L40P100BT (IHL\*)



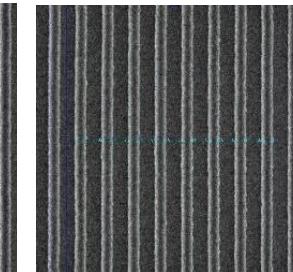
L40P100TB (NVL\*)



L40P100BM (IVL\*)

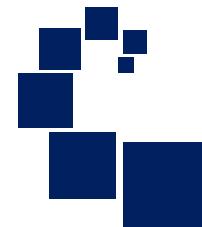


L40P100BB (NHS\*)



\* Coding labels for CD data results files

# 46JGZ072SJA3 (2247EMEM001 slot 2) Reference Data



## L40P100 Anchor Target

Nov 2022

- All measurements in nm.
- Avg CD and 1sigma line-to-line variation for L40P100 anchor target for each die, reported for each die in wafer map format, and plotted to right.
- Average and 1sigma values are of 8 lines sampled at each site, from images on next page.
- CD values convey bottom CD of the lines.

Full Wafer Avg CD:	44.39	nm
Full wafer 1sigma CD:	1.58	nm
Die-to-Die 1sigma		
Avg:	0.24	nm
RMS:	0.30	nm
LWR Line (Avg):	2.39	nm
FOV:	1000	nm

Average of all individual die CD averages (8 targets/die).

Stdev of all die CD average of (8 targets/die), represents across wafer variation.

Feature-to-feature variation within grating.

Arithmetic average value of feature-to-feature variation.

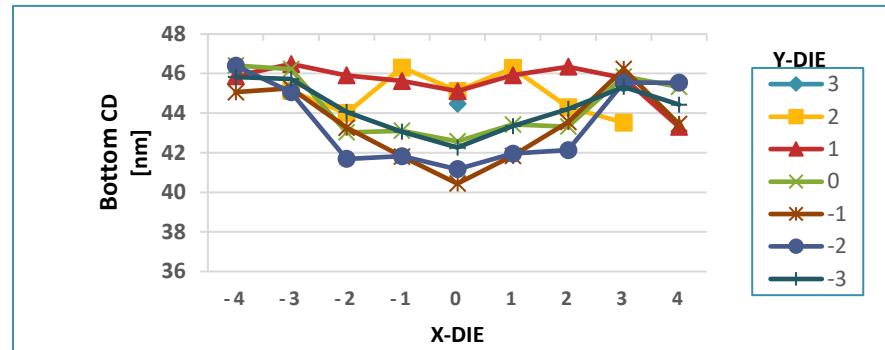
RMS average value of feature-to-feature variation.

Average of 3Sigma LWR (Linewidth)

Size of image (field-of-view).

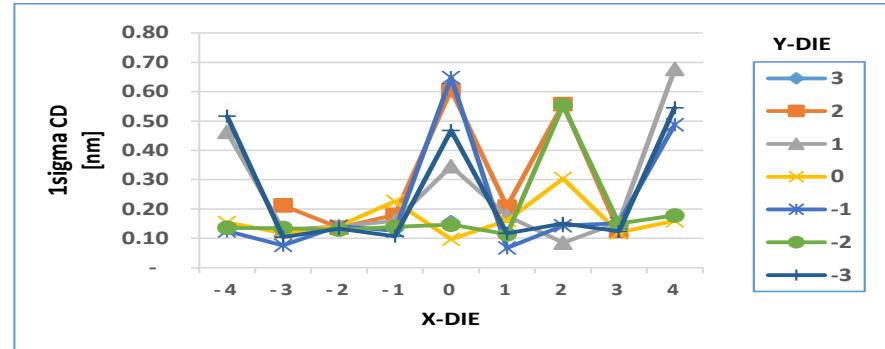
## L40P100 Anchor Target Avg CD (line)

	-4	-3	-2	-1	0	1	2	3	4
4					44.47				
3		45.11	43.99	46.30	45.12	46.27	44.30	43.52	
2	45.87	46.48	45.91	45.62	45.11	45.91	46.34	45.77	43.30
1	46.40	46.23	43.03	43.11	42.57	43.42	43.32	45.85	45.32
0	45.05	45.25	43.26	41.81	40.44	41.84	43.54	46.23	43.45
-1	46.40	45.05	41.69	41.82	41.17	41.95	42.13	45.54	45.53
-2	45.82	45.72	44.06	43.06	42.26	43.34	44.21	45.32	44.42
-3		46.65	44.16	45.08	44.34	45.32	43.90	45.01	



## L40P100 Anchor Target 1sigma CD

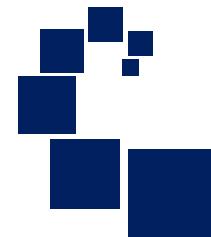
	-4	-3	-2	-1	0	1	2	3	4
4					0.16				
3		0.21	0.14	0.18	0.61	0.21	0.56	0.13	
2	0.46	0.13	0.14	0.16	0.35	0.18	0.08	0.15	0.68
1	0.15	0.12	0.14	0.23	0.10	0.16	0.30	0.12	0.16
0	0.13	0.08	0.14	0.13	0.65	0.07	0.14	0.15	0.49
-1	0.14	0.13	0.13	0.14	0.15	0.11	0.55	0.15	0.18
-2	0.52	0.10	0.13	0.11	0.47	0.12	0.15	0.12	0.55
-3		0.13	0.19	0.23	0.67	0.17	0.74	0.18	



# 46JGZ072SJA3 (2247EMEM001 slot 2) Reference Data

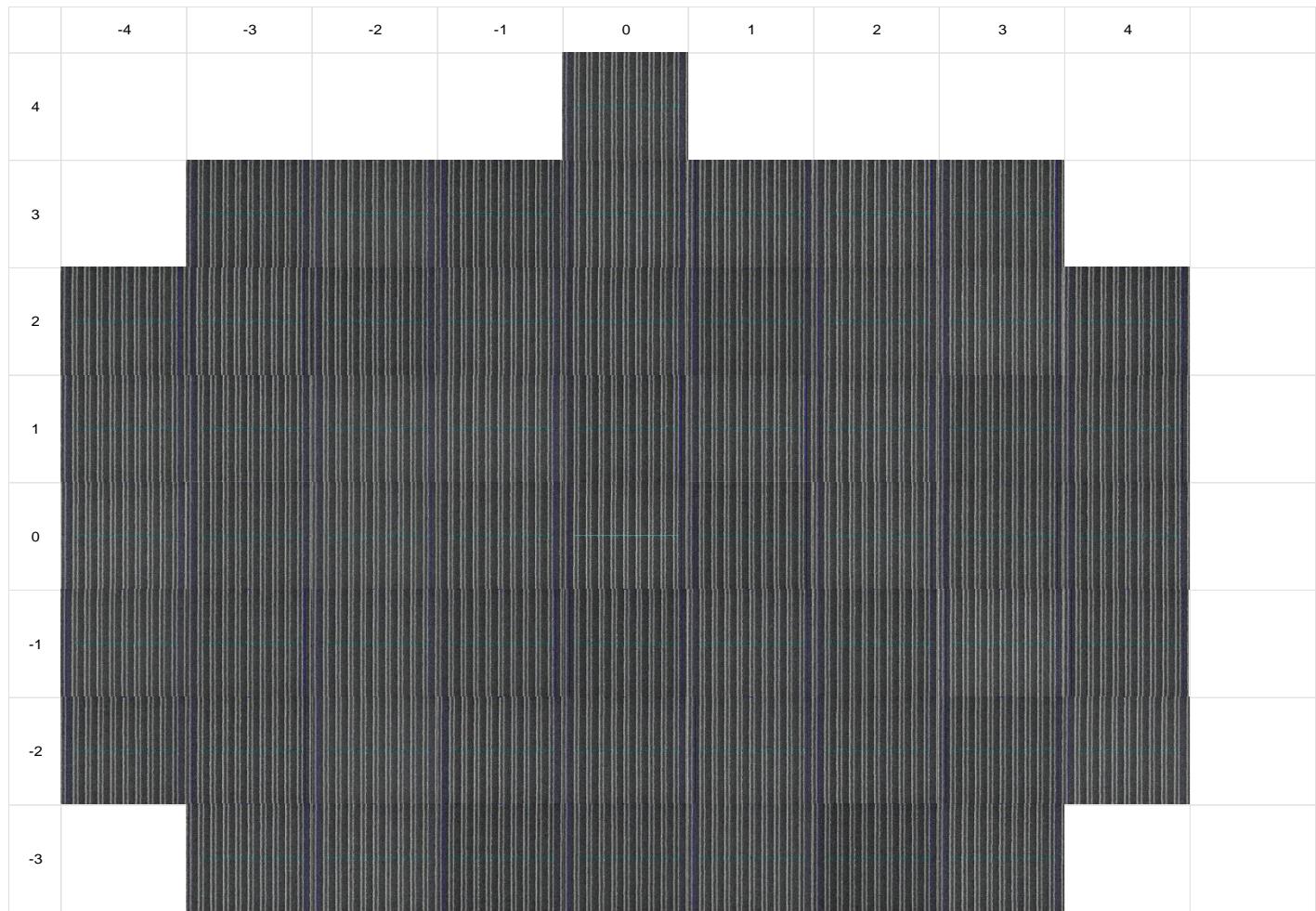
L40P100 Anchor Target

Nov 2022



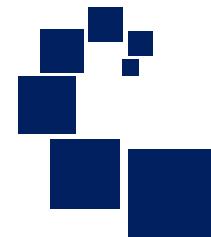
**L40P100 Anchor Target**  
CD-SEM image wafer map

Full Wafer Avg CD:	44.39	nm
Full wafer 1sigma CD:	1.58	nm
Die-to-Die 1sigma		
Avg:	0.24	nm
RMS:	0.30	nm
LWR Line (Avg):	2.39	nm
FOV:	1000	nm



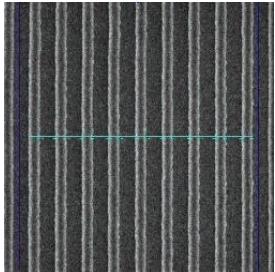
# 46JGZ072SJA3 (2247EMEM001 slot 2) Reference Data

Secondary Targets  
Nov 2022



## Anchor Target

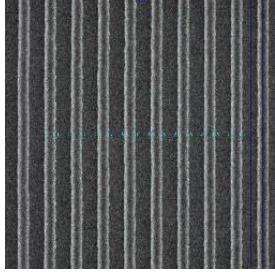
L40P100 (XLS\*)



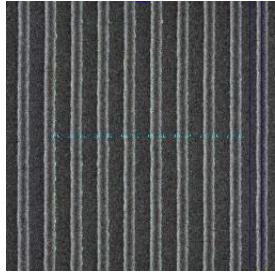
Full Wafer Avg CD:	44.39	nm
Full wafer 1sigma CD:	1.58	nm
Die-to-Die 1 sigma		
Avg:	0.24	nm
RMS:	0.30	nm
LWR Line (Avg):	2.39	nm
FOV:	1000	nm

## Secondary Targets

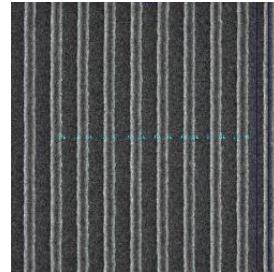
L40P100TT (NHL\*)



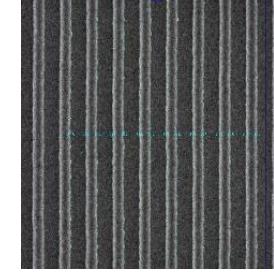
L40P100BT (IHL\*)



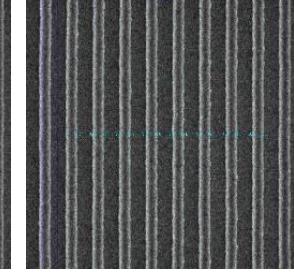
L40P100TB (NVL\*)



L40P100BM (IVL\*)

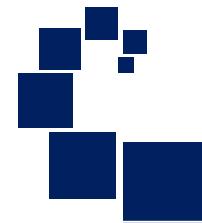


L40P100BB (NHS\*)



\* Coding labels for CD data results files

# 46JJX083SJE3 (2247EMEM001 slot 2) Reference Data



## L40P100 Anchor Target

Nov 2022

- All measurements in nm.
- Avg CD and 1sigma line-to-line variation for L40P100 anchor target for each die, reported for each die in wafer map format, and plotted to right.
- Average and 1sigma values are of 8 lines sampled at each site, from images on next page.
- CD values convey bottom CD of the lines.

Full Wafer Avg CD:	43.85	nm
Full wafer 1sigma CD:	1.39	nm
Die-to-Die 1sigma		
Avg:	0.25	nm
RMS:	0.36	nm
LWR Line (Avg):	2.57	nm
FOV:	1000	nm

Average of all individual die CD averages (8 targets/die).

Stddev of all die CD average of (8 targets/die), represents across wafer variation.

Feature-to-feature variation within grating.

Arithmetic average value of feature-to-feature variation.

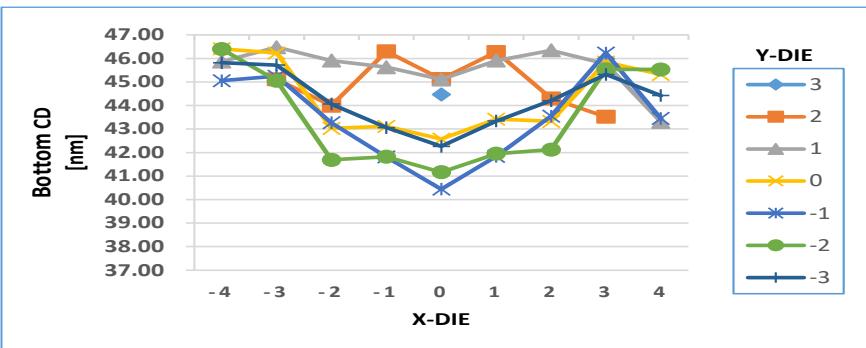
RMS average value of feature-to-feature variation.

Average of 3Sigma LWR (Linewidth)

Size of image (field-of-view).

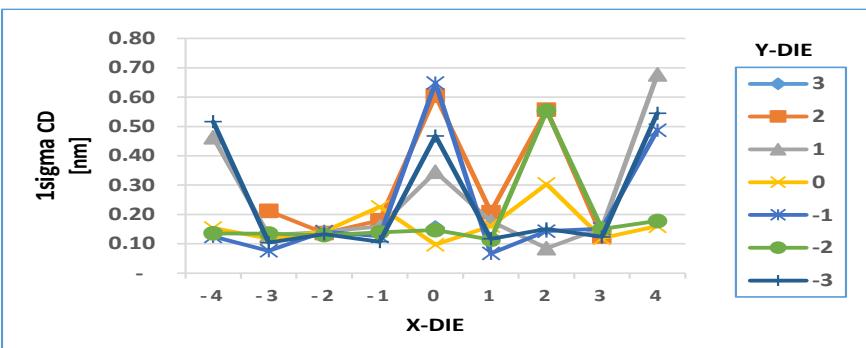
## L40P100 Anchor Target Avg CD (line)

	-4	-3	-2	-1	0	1	2	3	4
4					43.49				
3		44.03	44.43	45.59	44.19	45.47	43.57	43.04	
2	44.50	45.98	45.60	45.23	43.60	45.72	45.85	45.43	42.35
1	45.55	45.47	42.56	43.41	42.96	43.44	42.89	45.53	44.63
0	44.12	45.37	43.30	41.97	40.57	42.06	43.63	44.98	42.41
-1	46.01	44.89	41.83	41.77	41.24	41.89	41.72	44.74	43.95
-2	44.09	45.32	44.02	42.99	42.21	42.97	43.92	44.54	42.17
-3		45.62	43.56	44.66	42.05	44.84	43.49	43.40	

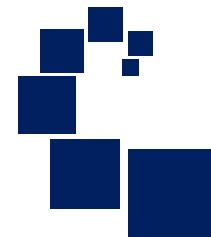


## L40P100 Anchor Target 1sigma CD

	-4	-3	-2	-1	0	1	2	3	4
4					0.16				
3		0.21	0.14	0.18	0.61	0.21	0.56	0.13	
2	0.46	0.13	0.14	0.16	0.35	0.18	0.08	0.15	0.68
1	0.15	0.12	0.14	0.23	0.10	0.16	0.30	0.12	0.16
0	0.13	0.08	0.14	0.13	0.65	0.07	0.14	0.15	0.49
-1	0.14	0.13	0.13	0.14	0.15	0.11	0.55	0.15	0.18
-2	0.52	0.10	0.13	0.11	0.47	0.12	0.15	0.12	0.55
-3		0.13	0.19	0.23	0.67	0.17	0.74	0.18	



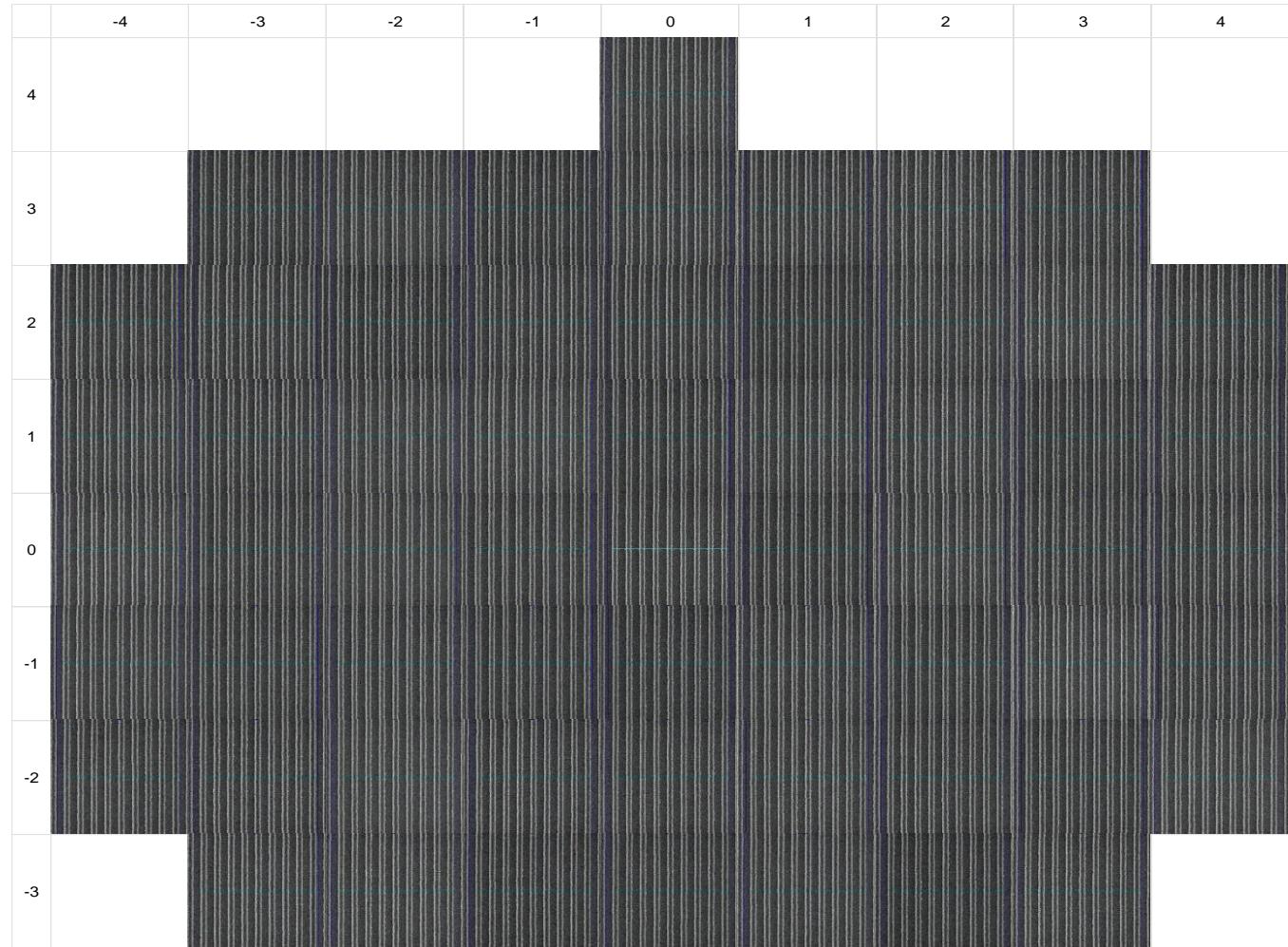
# 46JJX083SJE3 (2247EMEM001 slot 2) Reference Data



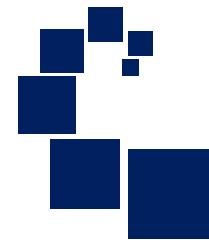
L40P100 Anchor Target  
Nov 2022

## L40P100 Anchor Target CD-SEM image wafer map

Full Wafer Avg CD:	43.85	nm
Full wafer 1sigma CD:	1.39	nm
Die-to-Die 1sigma		
Avg:	0.25	nm
RMS:	0.36	nm
LWR Line (Avg):	2.57	nm
FOV:	1000	nm



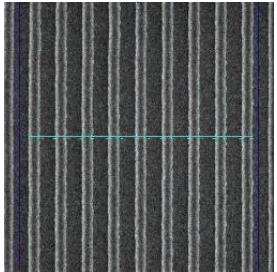
# 46JJX083SJE3 (2247EMEM001 slot 2) Reference Data



Secondary Targets  
Nov 2022

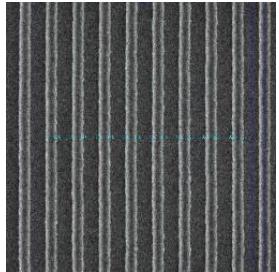
## Anchor Target

L40P100 (XLS\*)



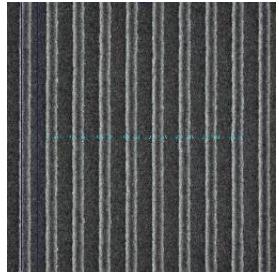
Full Wafer Avg CD:	43.85	nm
Full wafer 1sigma CD:	1.39	nm
Die-to-Die 1 sigma		
Avg:	0.25	nm
RMS:	0.36	nm
LWR Line (Avg):	2.57	nm
FOV:	1000	nm

L40P100TT (NHL\*)



Full Wafer Avg CD:	44.3	nm
Full wafer 1sigma CD:	1.45	nm
Die-to-Die 1 sigma		
Avg:	0.13	nm
RMS:	0.14	nm
LWR Line (Avg):	2.34	nm
FOV:	1000	nm

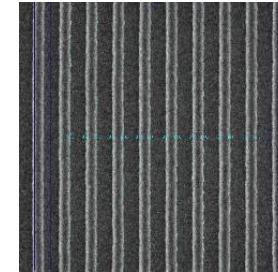
L40P100BT (IHL\*)



Full Wafer Avg CD:	44.6	nm
Full wafer 1sigma CD:	1.67	nm
Die-to-Die 1 sigma		
Avg:	0.15	nm
RMS:	0.16	nm
LWR Line (Avg):	2.44	nm
FOV:	1000	nm

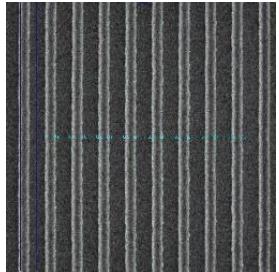
## Secondary Targets

L40P100TB (NVL\*)



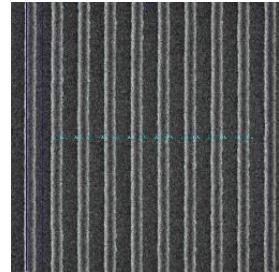
Full Wafer Avg CD:	43.9	nm
Full wafer 1sigma CD:	1.56	nm
Die-to-Die 1 sigma		
Avg:	0.14	nm
RMS:	0.14	nm
LWR Line (Avg):	2.31	nm
FOV:	1000	nm

L40P100BM (IVL\*)



Full Wafer Avg CD:	44.2	nm
Full wafer 1sigma CD:	1.92	nm
Die-to-Die 1 sigma		
Avg:	0.32	nm
RMS:	0.44	nm
LWR Line (Avg):	2.47	nm
FOV:	1000	nm

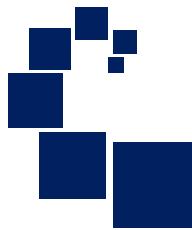
L40P100BB (NHS\*)



Full Wafer Avg CD:	45.0	nm
Full wafer 1sigma CD:	1.64	nm
Die-to-Die 1 sigma		
Avg:	0.14	nm
RMS:	0.14	nm
LWR Line (Avg):	2.35	nm
FOV:	1000	nm

\* Coding labels for CD data results files

# 46JJT004SJA5 (2247EMEM001 slot 3) Reference Data



## L40P100 Anchor Target

Nov 2022

- All measurements in nm.
- Avg CD and 1sigma line-to-line variation for L40P100 anchor target for each die, reported for each die in wafer map format, and plotted to right.
- Average and 1sigma values are of 8 lines sampled at each site, from images on next page.
- CD values convey bottom CD of the lines.

Full Wafer Avg CD:	44.29	nm
Full wafer 1sigma CD:	1.48	nm
Die-to-Die 1sigma		
Avg:	0.25	nm
RMS:	0.34	nm
LWR Line (Avg):	2.43	nm
FOV:	1000	nm

Average of all individual die CD averages (8 targets/die).

Stdev of all die CD average of (8 targets/die), represents across wafer variation.

Feature-to-feature variation within grating.

Arithmetic average value of feature-to-feature variation.

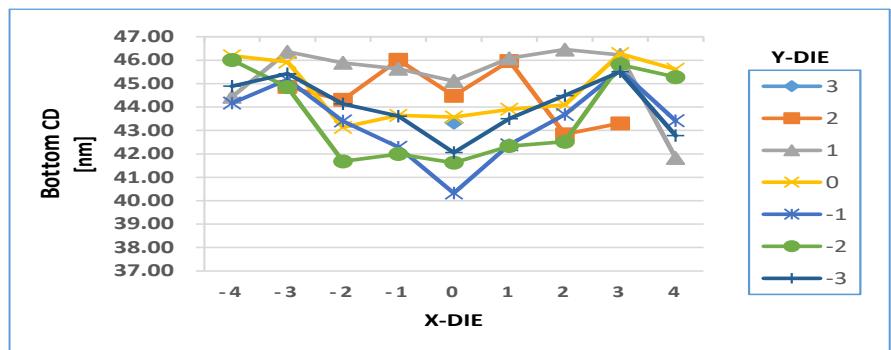
RMS average value of feature-to-feature variation.

Average of 3Sigma LWR (Linewidth)

Size of image (field-of-view).

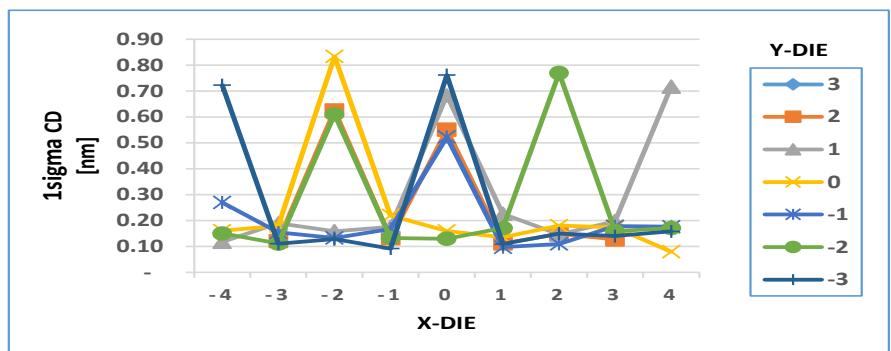
## L40P100 Anchor Target Avg CD (line)

	-4	-3	-2	-1	0	1	2	3	4
4					43.33				
3		44.86	44.31	46.02	44.48	45.97	42.83	43.30	
2	44.43	46.36	45.89	45.63	45.11	46.08	46.45	46.23	41.82
1	46.19	45.92	43.13	43.64	43.57	43.90	44.09	46.28	45.61
0	44.17	45.17	43.40	42.28	40.33	42.39	43.68	45.58	43.41
-1	46.01	44.84	41.68	41.99	41.62	42.33	42.52	45.81	45.28
-2	44.89	45.43	44.14	43.61	42.06	43.50	44.49	45.51	42.78
-3		45.87	43.40	44.97	44.42	45.29	44.23	44.71	



## L40P100 Anchor Target 1sigma CD

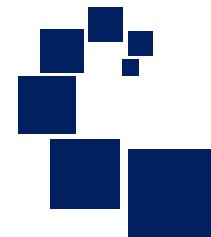
	-4	-3	-2	-1	0	1	2	3	4
4					0.13				
3		0.12	0.63	0.13	0.55	0.11	0.15	0.13	
2	0.12	0.19	0.16	0.18	0.68	0.23	0.15	0.20	0.72
1	0.16	0.18	0.83	0.22	0.16	0.14	0.18	0.17	0.08
0	0.27	0.15	0.13	0.17	0.52	0.10	0.11	0.18	0.18
-1	0.15	0.11	0.61	0.13	0.13	0.17	0.77	0.16	0.17
-2	0.72	0.11	0.13	0.09	0.76	0.11	0.15	0.14	0.16
-3		0.21	0.12	0.12	0.35	0.13	0.94	0.16	



# 46JJT004SJA5 (2247EMEM001 slot 3) Reference Data

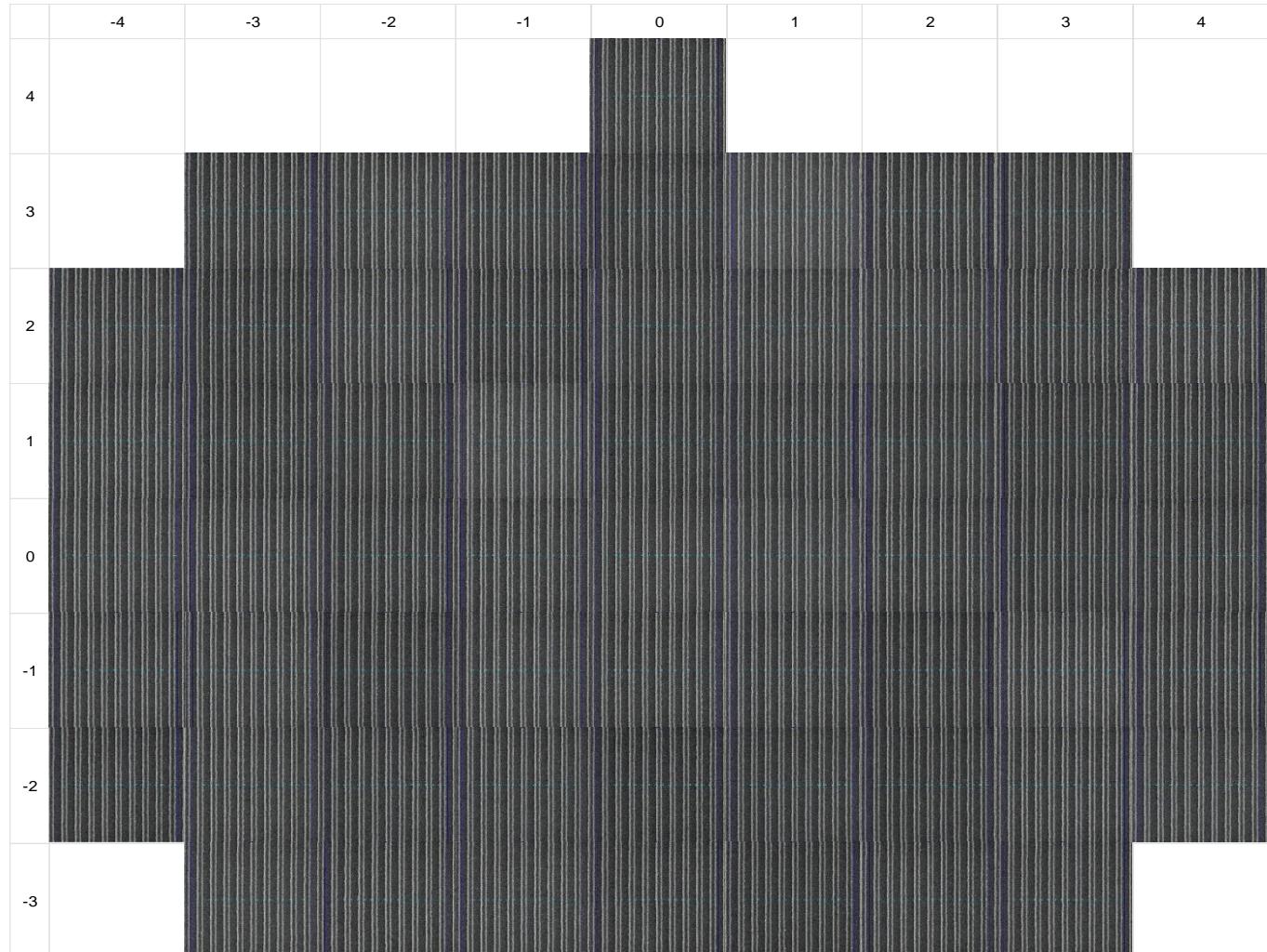
L40P100 Anchor Target

Nov 2022

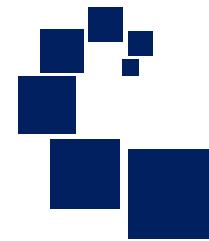


**L40P100 Anchor Target**  
CD-SEM image wafer map

Full Wafer Avg CD:	44.29	nm
Full wafer 1sigma CD:	1.48	nm
Die-to-Die 1sigma		
Avg:	0.25	nm
RMS:	0.34	nm
LWR Line (Avg):	2.43	nm
FOV:	1000	nm



# 46JJT004SJA5 (2247EMEM001 slot 3) Reference Data



Secondary Targets  
Nov 2022

## Anchor Target

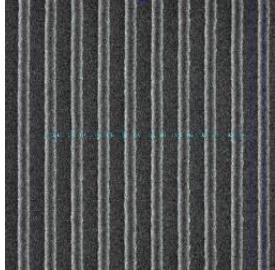
L40P100 (XLS\*)



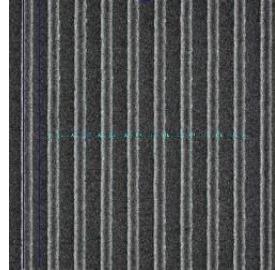
Full Wafer Avg CD:	44.29	nm
Full wafer 1sigma CD:	1.48	nm
Die-to-Die 1sigma		
Avg:	0.25	nm
RMS:	0.34	nm
LWR Line (Avg):	2.43	nm
FOV:	1000	nm

## Secondary Targets

L40P100TT (NHL\*)



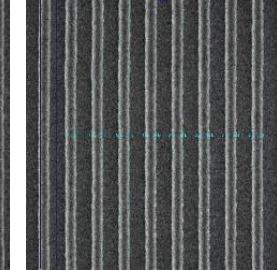
L40P100BT (IHL\*)



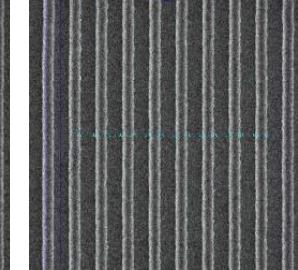
L40P100TB (NVL\*)



L40P100BM (IVL\*)

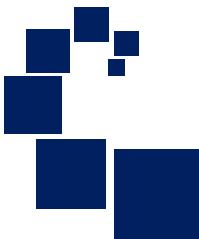


L40P100BB (NHS\*)

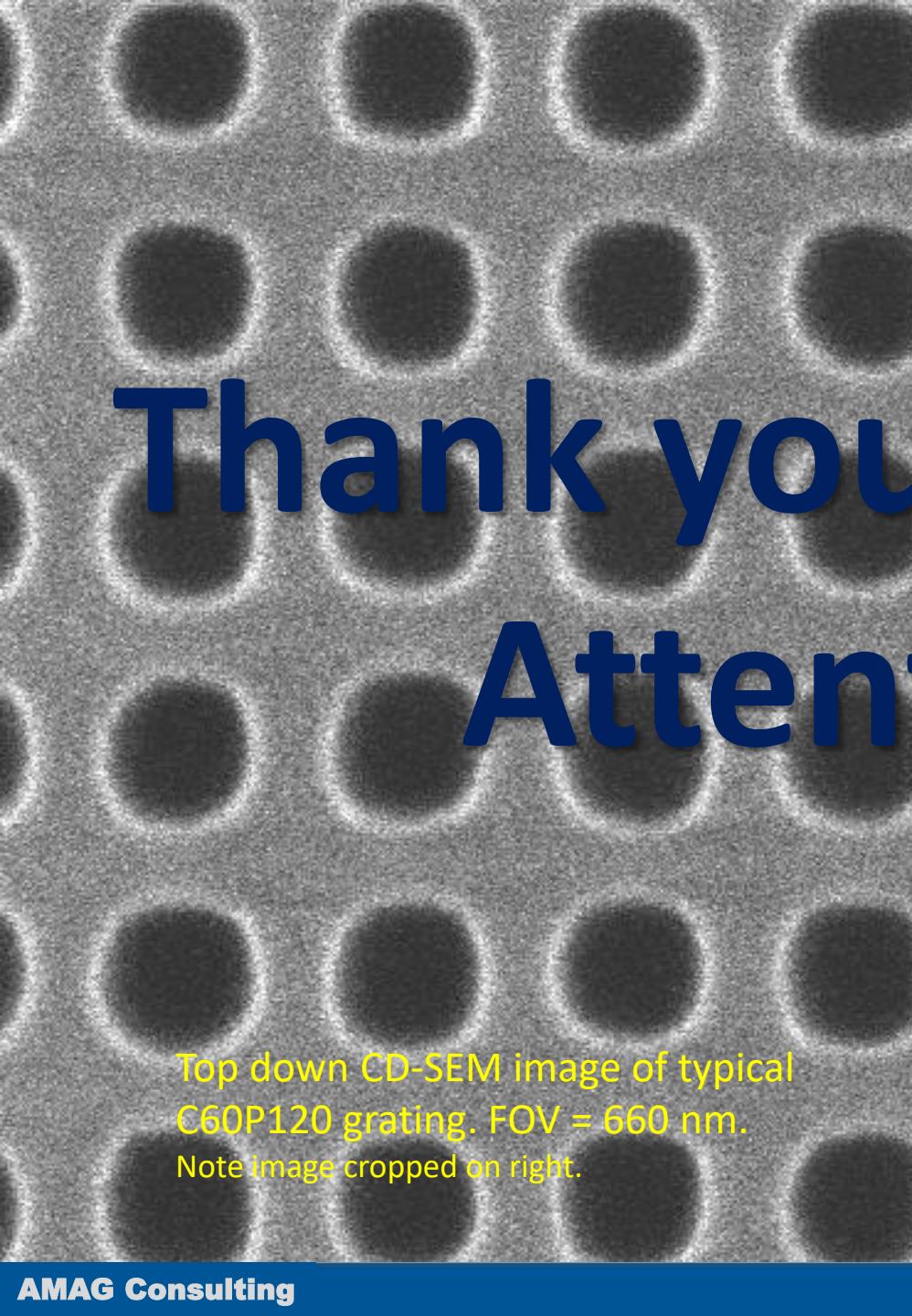


\* Coding labels for CD data results files

# Conclusions

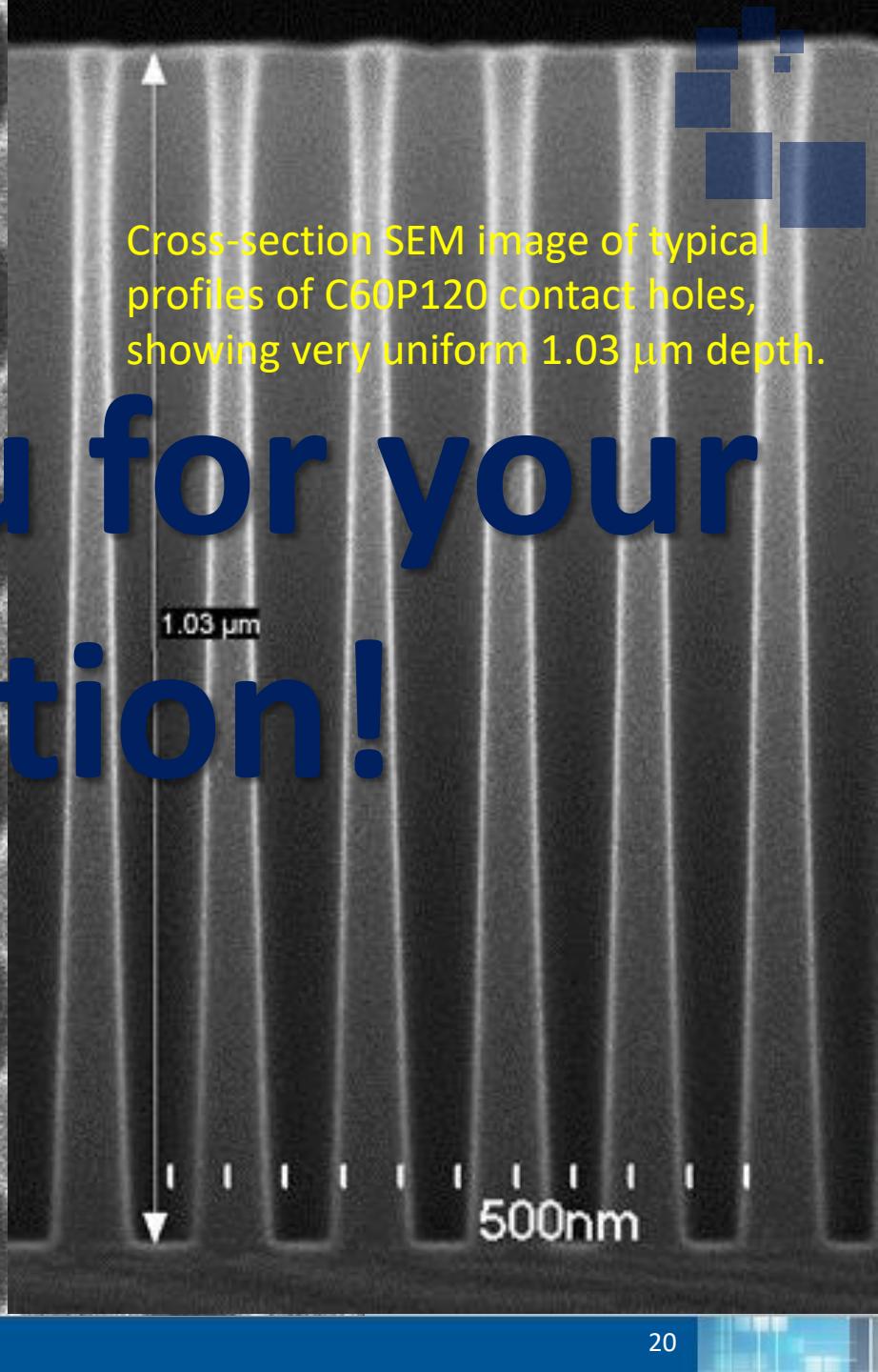


- Thank you for your purchase of AMAG HAR wafers!
- We hope this guide of reference CD-SEM metrology adds significant value to the use of these wafers.
- This report represents the standard metrology AMAG nanometro provides for such wafers, and future lots and wafer types will have similar companion data sets.



# Thank you for your Attention!

Top down CD-SEM image of typical C60P120 grating. FOV = 660 nm.  
Note image cropped on right.



Cross-section SEM image of typical profiles of C60P120 contact holes, showing very uniform 1.03  $\mu$ m depth.

1.03  $\mu$ m

500nm