ATR35 Wafer Specification

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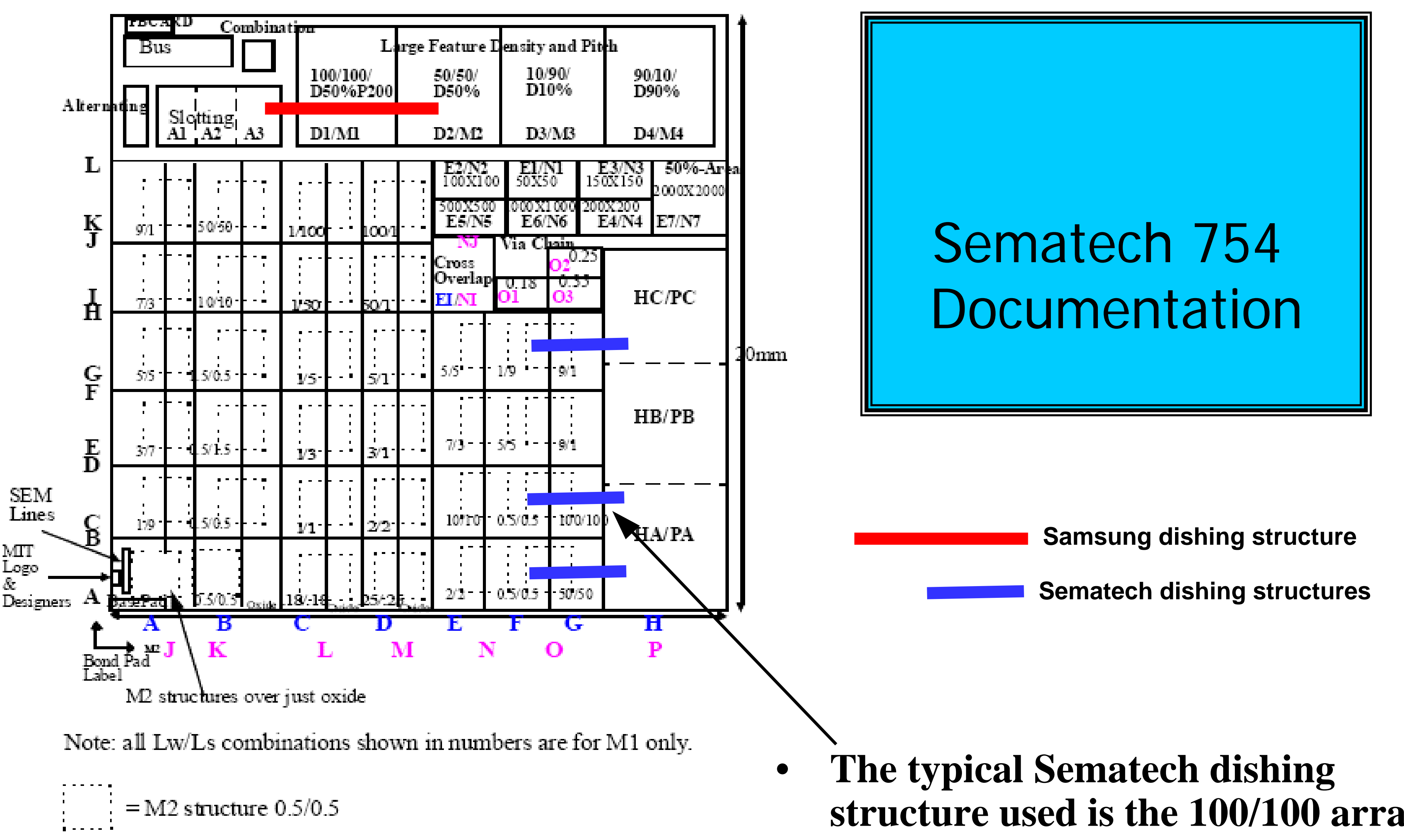
Sematech 754 Layout

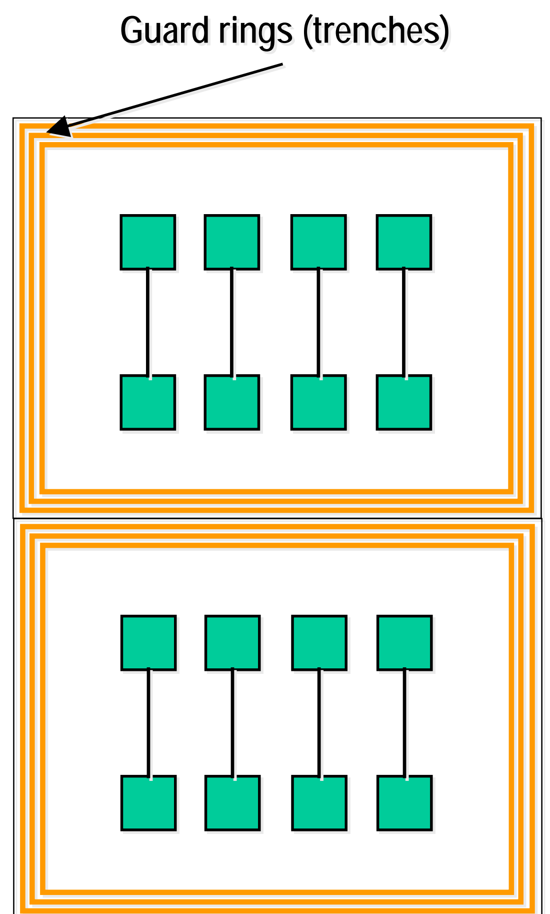


ATR35 Capabilities

Key BU's :
↗ All

ATR35 Description

- Reduction in critical dimensions
  - Minimum metal line width: 60nm
  - Via sizes down to 80nm
  - Via chains with up to ~10 million vias
- Expanded and improved set of reliability testers
  - Guard rings added to prevent low-k moisture adsorption



Structures down to 45nm node

ATR35 Layout

STI LONG SI LINES | STI OFFSET C1 | SEM_BARS | VIA SEMS | PVD TOV V 9000 | PVD T V 9000 | CIC LINES SPACE | STI STANDARD C2 | fill patt

Row	Left area		Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9
1			VIA1K_90	VIA1KD_90	CMB_SRP_SRS_M1	CMB_SRP_SRS_M2	VIA1K_SPRN_M2	CMB_SRP_SRL_M1	CMB_SRP_SRL_M2	VIA1K_LRNG_M2	VIA1K_M2SM_M2
2			CSRP	CMB_SRP	CMB_SRP	CSRP	CSRP	CMB_SRP	CMB_SRP	CSRP	EF
3			_YLD_110_M1	_LRS_M1	_LRS_M2	_YLD_110_M2	_YLD_140_180	_LRL_M1	_LRL_M2	_YLD_140_180	_UNDERPLATING
4							_M1			_M2	_A
5											
6											
7			CHN_V1	CHN_V1_	CHN_V1_	LW_M1_N	nvls_EM_6M1L180	CMP_M1_A	CMP_PADS	VCOMB	VCOMB
8			_YLD_110_M2	_YLD_100_M2	_RNG_M2	LW_M2_N	nvls_EM_6M2L180			_BTS_NGR	_BTS
9			VCOMB_	VCOMB	pbcard_a	NVLS_BTS_M1_B	nvls_EM_6LV140		probe pads	_140_220_M1M2	_140_220_VTV
10			BTS_	_BTS_	CSRP	EM_VLV_M12V1	VSERP_140		PVD TOV_ V_1000 TV	EM_CHN	EM_CHN
11			140_220_M1M2	120_180_M1M2	_YLD_090_100		nvls_EM_6M1L120			_M120V120	_M120V120
12			1KCHN_V1_	CMB_SRP	_M2		nvls_EM_6M2L120	FILL PATTERN	CMP_M2_A	CMB_SRP	CMB_SRP
13			_070_180	_MRS_M1		EM_CHN_M12V1	nvls_EM_6LV120	PVD_T_H_1800		_MRL_M1	_MRL_M2
14			1KCHN_V1_	CHN_V1_			VSERP_120	probe pads		CHN_V1_	CHN_V1_
15			_120_400	_DYLD_100_M2	CSRP	EM_VLV_	NVLS_BTS_M1_A	PVD TOV_H_1800		_DYLD_120_M2	_YLD_120_M2
16			CHN_V1_MRL_	CHN_V1_	_YLD_090_100	M120V120	NVLS_BTS_M2_A			CHN_V1_	CHN_V1
17			_100_140_M2	DYLD_110_M2	_M1					_YLD_140_M2	_YLD_160_M2
18			CHN_V1_MRL_	CMB_SRP		EM_CHN_	CMP_TOPO_TESTER			V1OFF_X_180	V1OFF_X_140
19			_70_100_M2	_MRS_M2		M120V120					
20										ICD struct	
21	CIC L/S		VIA1K_90	VIA1KD_90	CMB_SRP_SRS_M1	CMB_SRP_SRS_M2	VIA1KE_SPRN_M2	CMB_SRP_SRL_M1	CMB_SRP_SRL_M2	VIA1K_LRNG_M2	VIA1KE_M2SM_M2
22	PVD T_H_3200		CSRP	CMB_SRP	CMB_SRP	CSRP	CSRP	CMB_SRP	CMB_SRP	CSRP	EF
23	PVD TOV_H_3200		_YLD_110_M1	_LRS_M1	_LRS_M2	_YLD_110_M2	_YLD_140_180	_LRL_M1	_LRL_M2	_YLD_140_180	_UNDERPLATING
24	STI LONG SI LINE	CMP_FANG1					_M1			_M2	_A
25	NVLS_BTS_NGR_M1										
26	CHN_V1_SRL_70_180_M2										
27	PLT_CMB_M1_A	CMP_FANG2	CHN_V1	CHN_V1_	CHN_V1_	LW_M1_N	nvls_EM_6M1L180	CMP_M1_A	CMP_M1_B	VCOMB	VCOMB
28	PLT_CMB_M1_B		_YLD_110_M2	_YLD_100_M2	_RNG_M2	LW_M2_N	nvls_EM_6M2L180			_BTS_NGR	_BTS
29	PLT_CMB_M1_C	CMP_FANG3	VCOMB	VCOMB	pbcard_a	NVLS_BTS_M1_B	nvls_EM_6LV140			_140_220_M1M2	_140_220_VTV
30	PLT_CMB_M2		_BTS_	_BTS_	CSRP	EM_VLV_M12V1	VSERP_140			EM_CHN_M12V1	EM_CHN_M12V1
31	LW_M2_IN	CMP_FANG4	140_220_M1M2	120_180_M1M2	_YLD_090_100		nvls_EM_6M1L120				
32	LW_M1_IN		1KCHN_V1_	CMB_SRP	_M2		nvls_EM_6M2L120	CMP_M2_B	CMP_M2_A	CMB_SRP	CMB_SRP
33	COR_SRP_M2	PVD_T_H_1400	_070_180	_MRS_M1		EM_CHN_M12V1	nvls_EM_6LV120			_MRL_M1	_MRL_M2
34	COR_PLTCMB_M2	PVD TOV_H	1KCHN_V1_	CHN_V1_			VSERP_120			CHN_V1_	CHN_V1_
35	COR_CMB_M2	1400	_120_400	_DYLD_100_M2	CSRP	EM_VLV_	NVLS_BTS_M1_A			_DYLD_120_M2	_YLD_120_M2
36	NVLS_SIMS	PVD TOV V 1400 / PVD TV	CHN_V1_MRL_	CHN_V1_	_YLD_090_100	M120V120	NVLS_BTS_M2_A			CHN_V1_	CHN_V1_
37			_100_140_M2	_DYLD_110_M2	_M1					_YLD_140_M2	_YLD_160_M2
38			CHN_V1_MRL_	CMB_SRP		EM_CHN_	EF_OVERPLATING_TESTER			V1OFF	V1OFF
39			_70_100_M2	_MRS_M2		M120V120				_X_180	_X_140

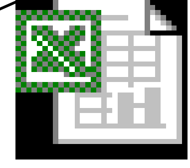
overall die size : x= 20.264 mm ; y= 19.250 mm

not to scale- row ht. is only 0.75x of scale (for better viewing)

Tester name in Red is the first set of testers. Blue is the second set of testers

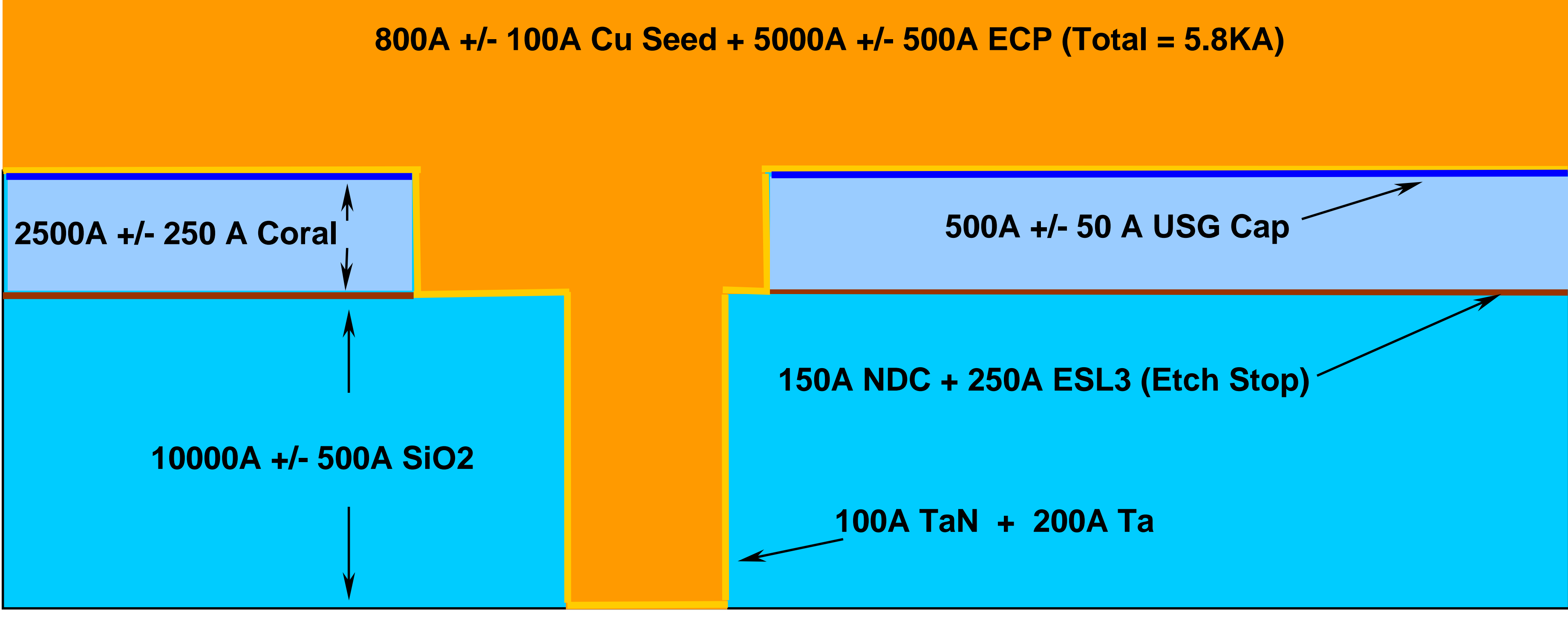
CMP Tester	Frame
EF Tester	ATR30 Testers
PVD Tester	

- Note the CMP test structures highlighted in light brown



ATR35 Layout

ATR M1 Film Stack



- Barrier CMP Target: Remove USG Cap + 200A Coral

ATR35 only available with Coral films

ATR Process Flow (up to M1 CMP)

Step	Operation	Hold? (Y)	Non-Std? (Y)	Split? (Y)	Recipe Name	Tools	Specification	date In	wfrs In	date Out	wfrs Out	Oper	Comments
1L 001	***STARTING MATERIAL***												
1L 002	***DIELECTRIC DEP.***												
1L 002a	Isolation dielectric				BL_USG_10kA_V1	13A or 14B	SiO_2, 10000 ± 500 Å						
1L 002b	Etch stop layer				BL_kStop_400A_V1	Bay 14B	H_2 / 150Å NDC / 250Å ESL3						
1L 002c	Line dielectric (M1)				BL_HMSCORAL_2500A_V2	Bay 14A	HMS Coral, 2500 ± 250 Å						
1L 002d	Adhesion treatment				BL_HePlasma_V1	Bay 14B	He plasma, static mode, 20"						
1L 002e	Cap layer				BL_TEOS_500A_V1	13A or 14A	TEOS, 500 ± 50 Å						
1L 002f	Defect measurement				USG_8633A_160nm_HS_M2M	SP1	TBD						Map to map with pre
1L 003	***PHOTOLITHOGRAPHY (M1 TRENCH)***												
1L 004	***DIELECTRIC ETCH / STRIP / CLEAN (M1 TRENCH)***												
1L 006	***PVD B/S*** **- Verify Cu electrofill is up before processing Time restriction: <5 days between PVD B/S and Cu fill Contact owner if time restriction exceeded.**												
	Flow				BL_PVD_140H_V1	Inova XT	Flow name						
	Degas				(BL_350C_90s_V1)	Inova XT	350 °C, 90"						
	Barrier				(BL_Ta_BKM4_V1)	Inova XT	100Å TaN - 150Å + 200Å Ta - 50Å						
	Seed				(BL_Cu_BKM4b_800A_V1)	Inova XT	800 + 100 Å						
1L 007	***Cu ELECTROFILL*** **- Time restriction: <24 hours between Cu fill and Cu anneal Contact owner if time restriction exceeded**												
	Cu fill				BL_ECu_5000A_V4	Sabre XT	5000 + 250 Å						
	Anneal					Sabre XT	225 °C, 90 sec.						
1L 009	***METAL POLISH*** **- Verify PECVD is up before processing Time restriction: <72 hours between Cu CMP and M2 Coral stack dep. Contact owner if time restriction exceeded**												
	Cu CMP				BL140H_M1_V2	Xceda	Stop on barrier						
	TaN CMP					Xceda	Remove TEOS cap + ~200Å Coral						
	Clean					Xceda	Surfaces clean						
	Inspection						No residual metal or particles						

ATR Test Structures

- Topography test structures
- Fang test structures
- Electrical test structures

Typical CIC Profilometry Locations

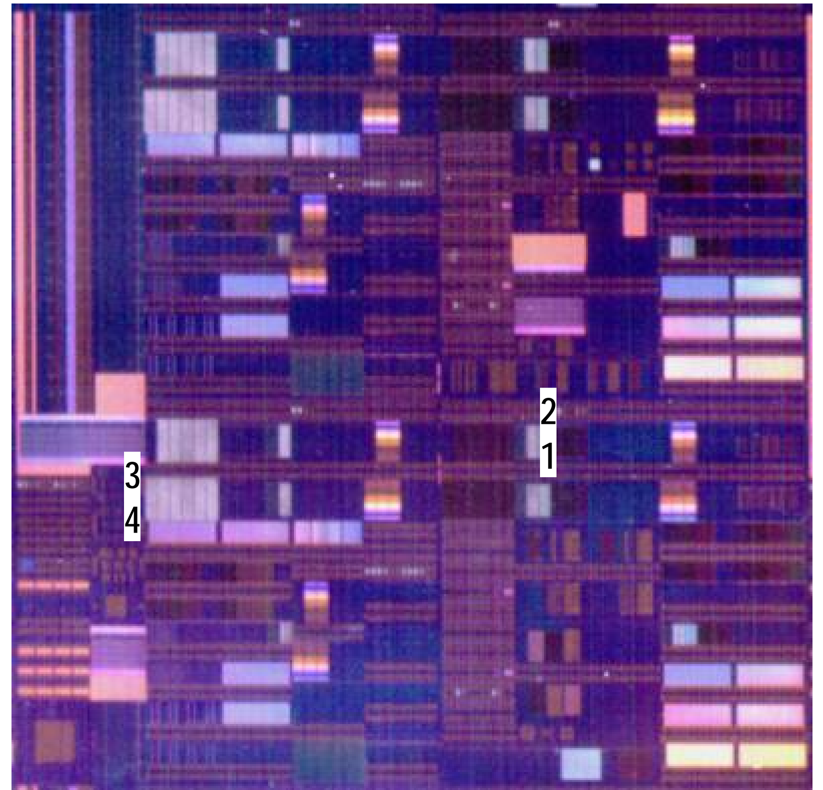
- New profilometry recipe was created to measure large and small E-test comb/serp structures in addition to CMP test structures.

New structures profiled:

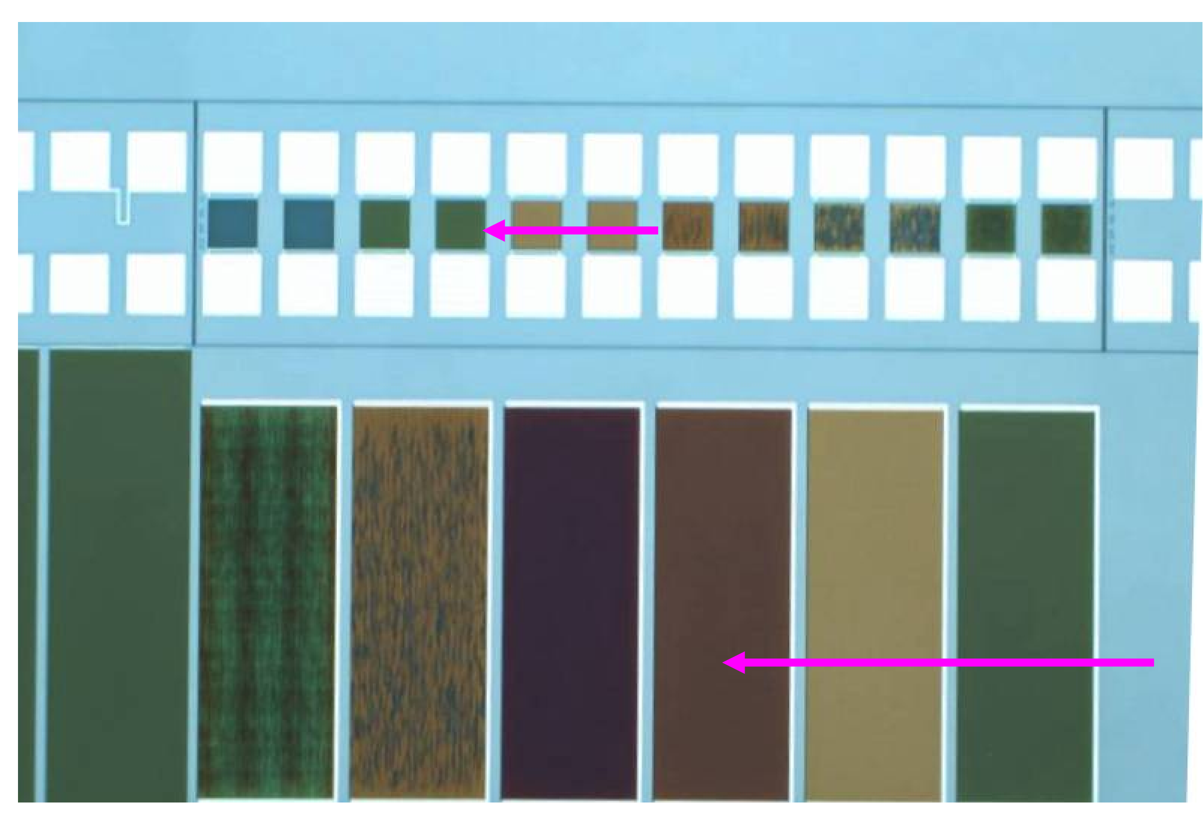
1. CMB_SRP_LRL_M1
2. CMB_SRP_SRL_M1

CMP test structures profiled:

3. FANG1 single line structures
4. FANG2 small pitch arrays



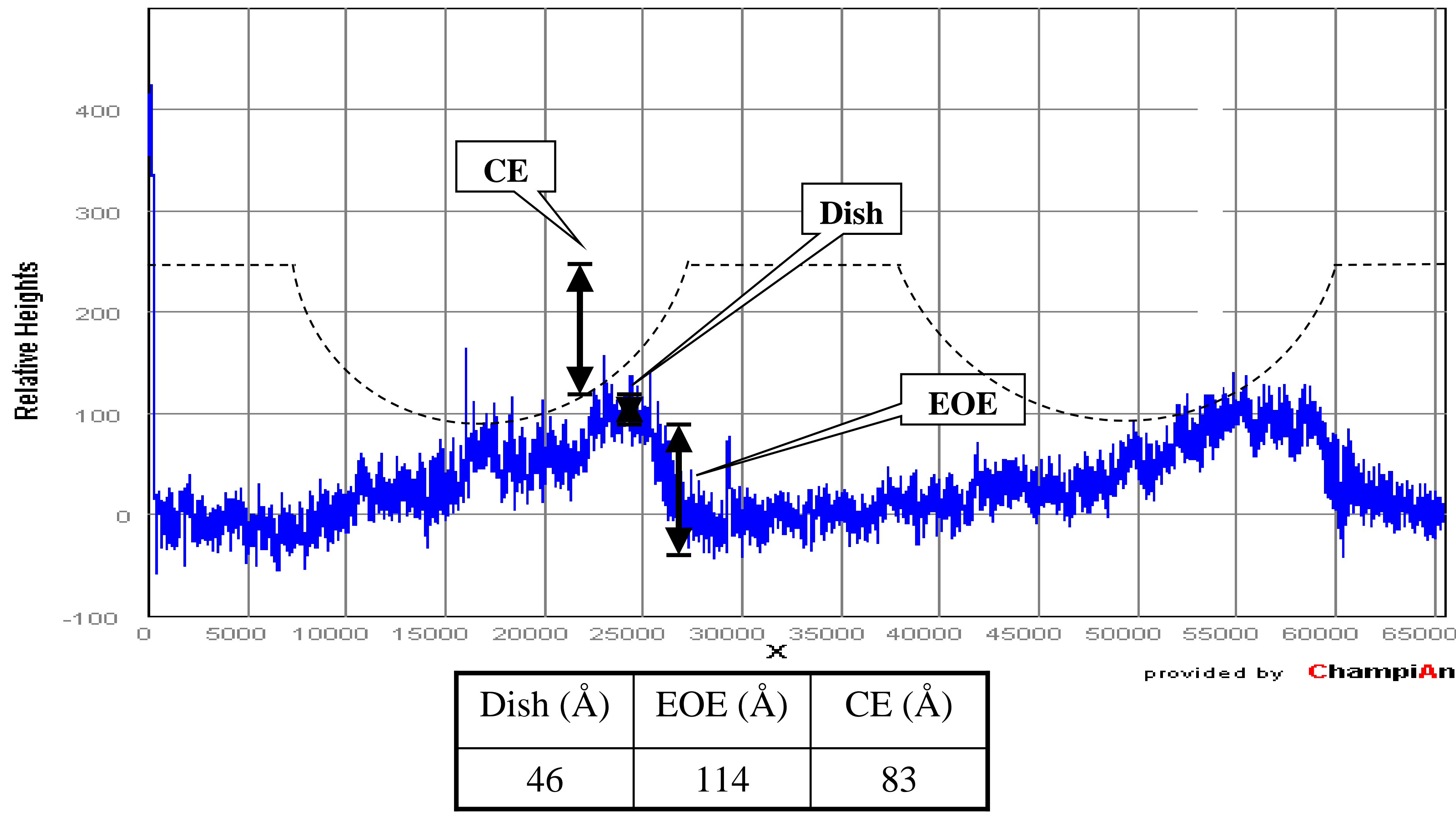
Serp/Comb Scan Locations



CMB_SRP_SRL_M1
DUTs 5 & 6 scanned
(140x140 nm)

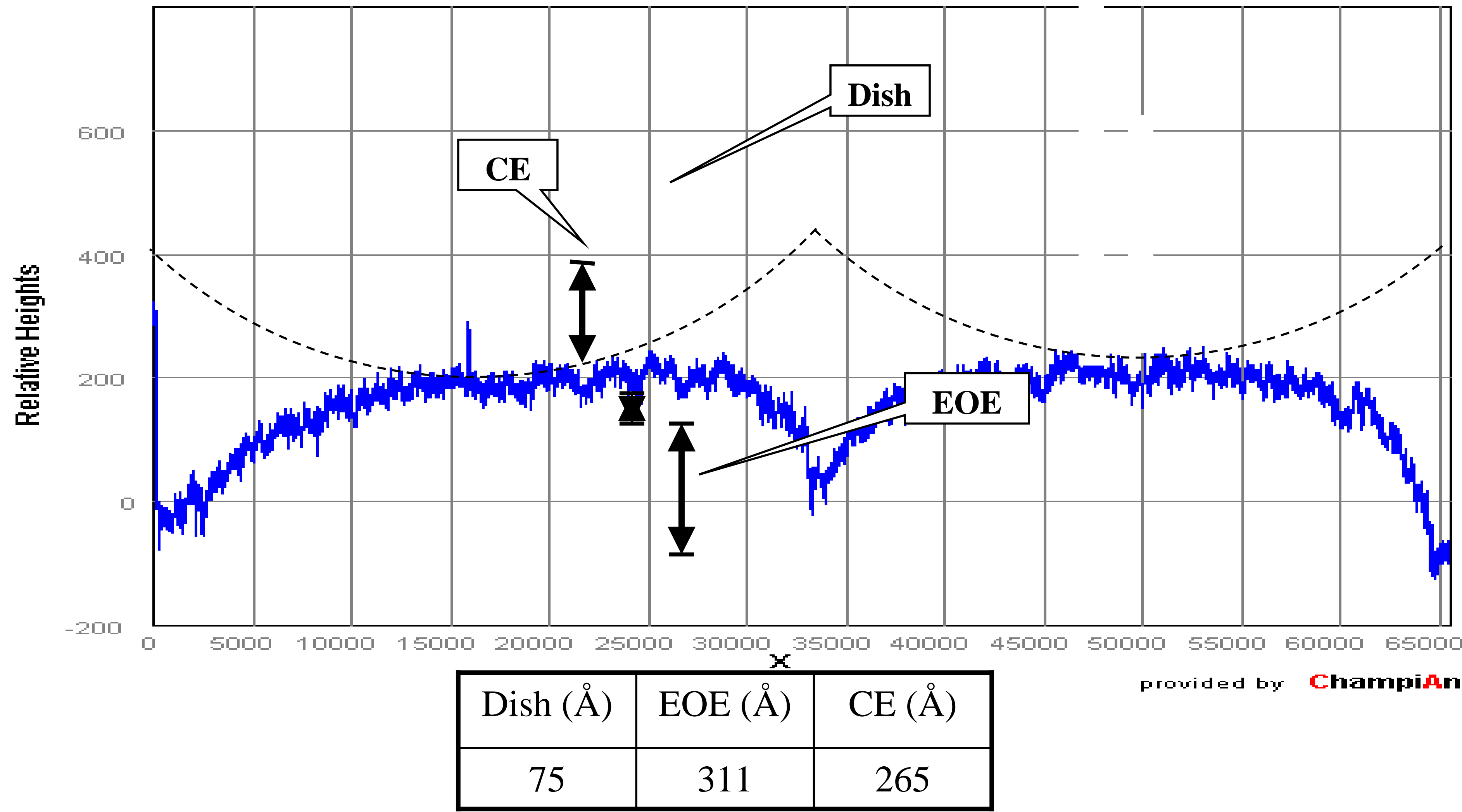
CMB_SRP_LRL_M1
DUTs 11 & 12 scanned
SERPs (140x140 nm, 180x180 nm)

CMB_SRP_SRL_M1 Surface Profile Scan



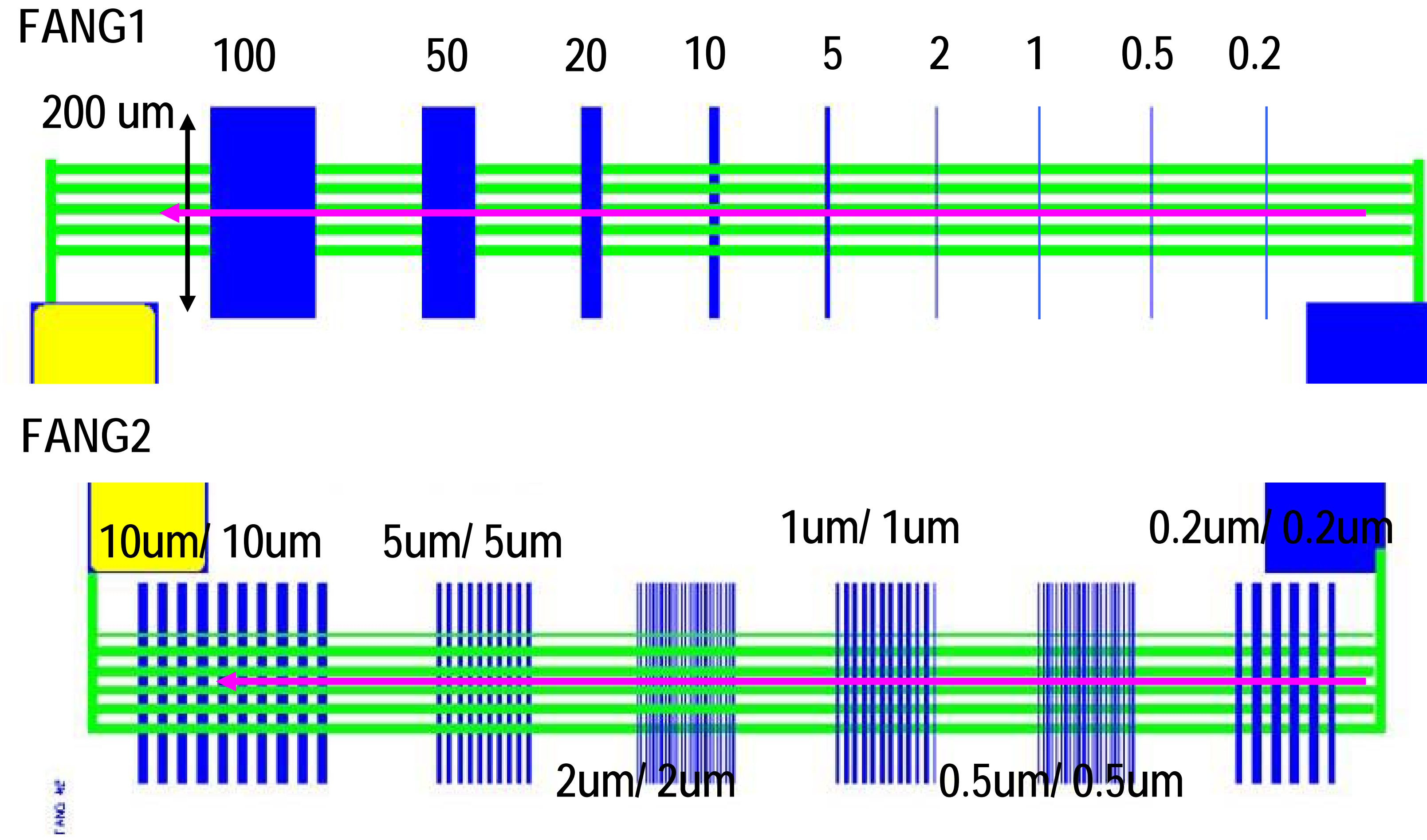
Dish (Å)	EOE (Å)	CE (Å)
46	114	83

CMB_SRP_LRL_M1 Surface Profile Scan



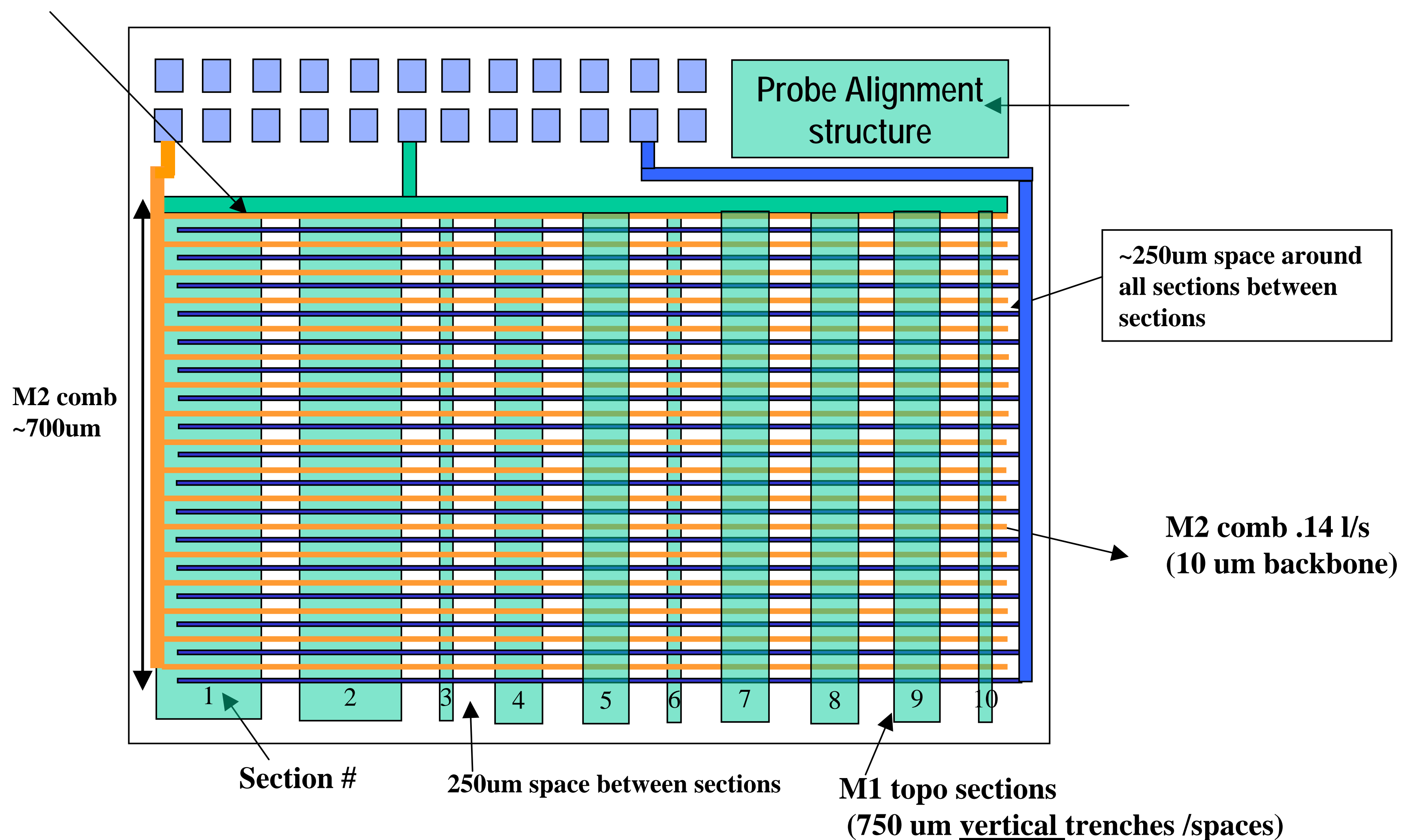
Dish (Å)	EOE (Å)	CE (Å)
75	311	265

CMP Test Structure Scan Locations



Topo Test Structures

CMP Topo Tester
(in place of via_chn_250_m3_upper)

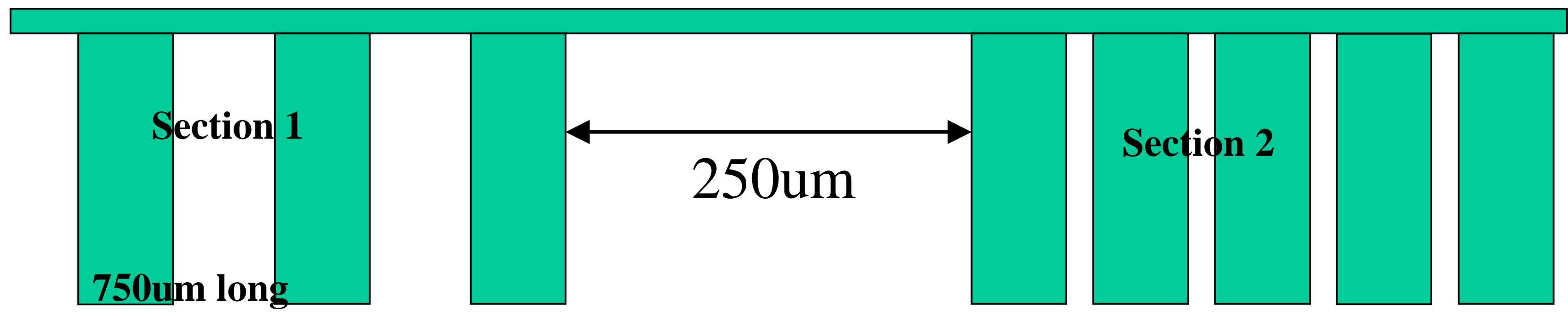


ATR35 CMP Topo Tester (in place of via_chn_250_m3_upper)

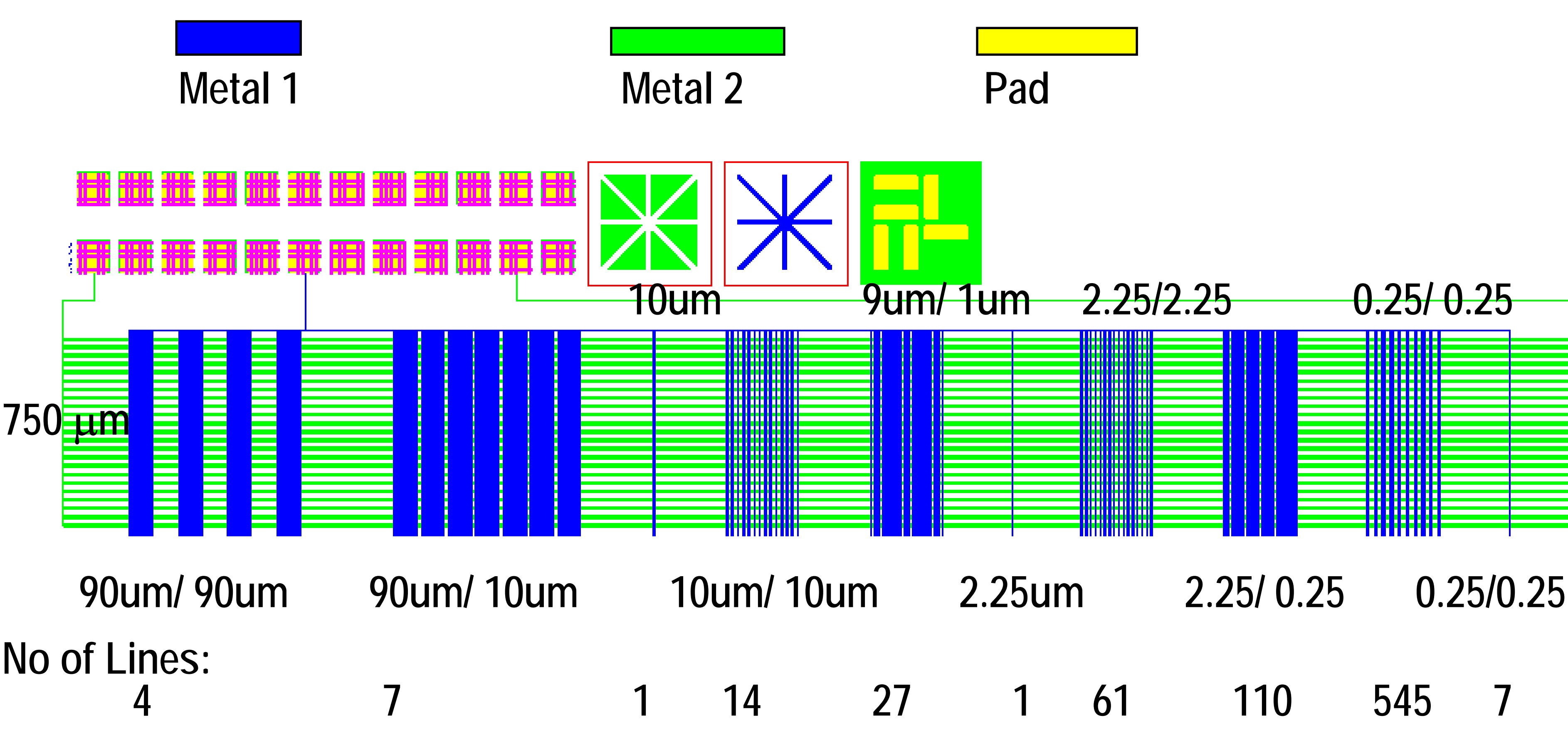
M1 topo

CMP Topography tester (replace via_chn_250_m3 in top portion)						tester width (mm) 5.58		
0.25	mm space between sections							
M1 topo (no vias)		M2 comb 140nm trench/140nm sp perpendicular to test for shorts (see ppt diagram)						
section	**trench (nm)**	**space (nm)**	**pitch (nm)**	**metal density**	**# repeats**	**tester x dim (mm)**	**total x dim (mm)**	**y-dim (um)**
1	90000	90000	180000	0.5	**4**	0.720	1.22	750
2	90000	10000	100000	0.9	**7**	0.700	2.17	750
3	10000			0.5	**1**	0.020	2.44	750
4	10000	10000	20000	0.5	**14**	0.280	2.97	750
5	9000	1000	10000	0.9	**27**	0.270	3.49	750
6	2250			0.5	**1**	0.005	3.74	750
7	2250	2250	4500	0.5	**61**	0.275	4.27	750
8	2250	250	2500	0.9	**110**	0.275	4.79	750
9	250	250	500	0.5	**550**	0.275	5.32	750
10	250	250	500	0.5	**7**	0.004	**5.57**	750

- Use a scaled version of this pattern as the topo sections under combs/serps (CS topo)
  - use horizontal trenches in these testers



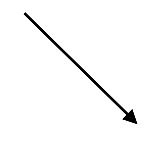
CMP_TOPO_Tester



Metal 2 COMB:
0.14 um / 0.14 um L/S

CMP Pad Tester

left side testers



left border	left sections	density	trench	space	height	pitch	# repeats	width
250	top border	0	0		200	0		
250	1 left	9.9	0.11	1	250	1.11	225	249.75
250	space	0	0		200	0		0
250	2 left	50	1	1	250	2	125	250
250	space	0	0		200	0		0
250	3 left	90	9	1	250	10	25	250
250	space	0	0		200	0		0
250	4 left	99	49	1	250	50	5	250
250	bot border	0	0		200	0		0
	total				2000			

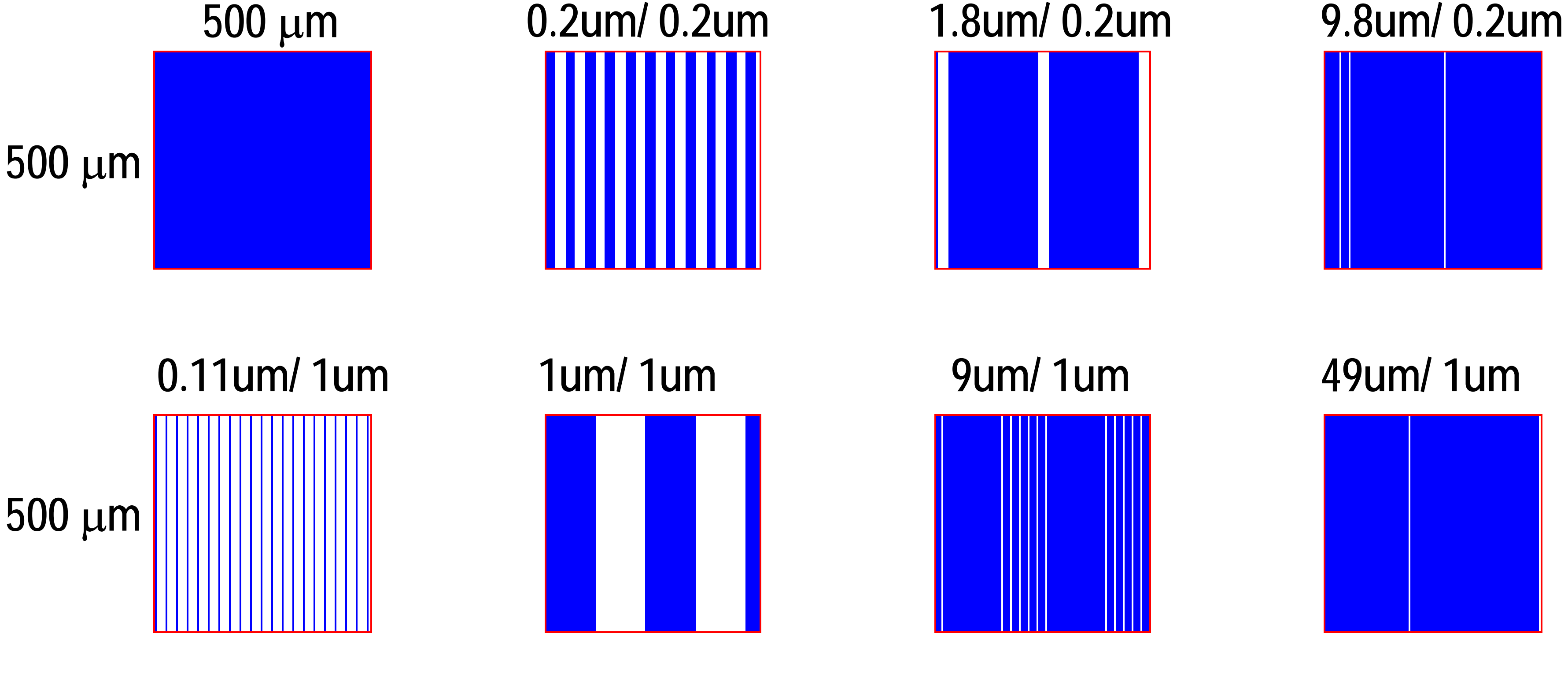
Right side testers

space (between lt & rt sect)	right sections	density	trench	space	pitch	# repeats	width	right border
234	space	0	0					250
234	1 right	100	250	0	250	1	250	250
234	space	0	0		0		0	250
234	2 right	50	0.2	0.2	0.4	625	250	250
234	space	0	0		0		0	250
234	3 right	90	1.8	0.2	2	125.000	250	250
234	space	0	0		0		0	250
234	4 right	99	9.8	0.2	10	25	250	250
234	space	0						250

Large pad

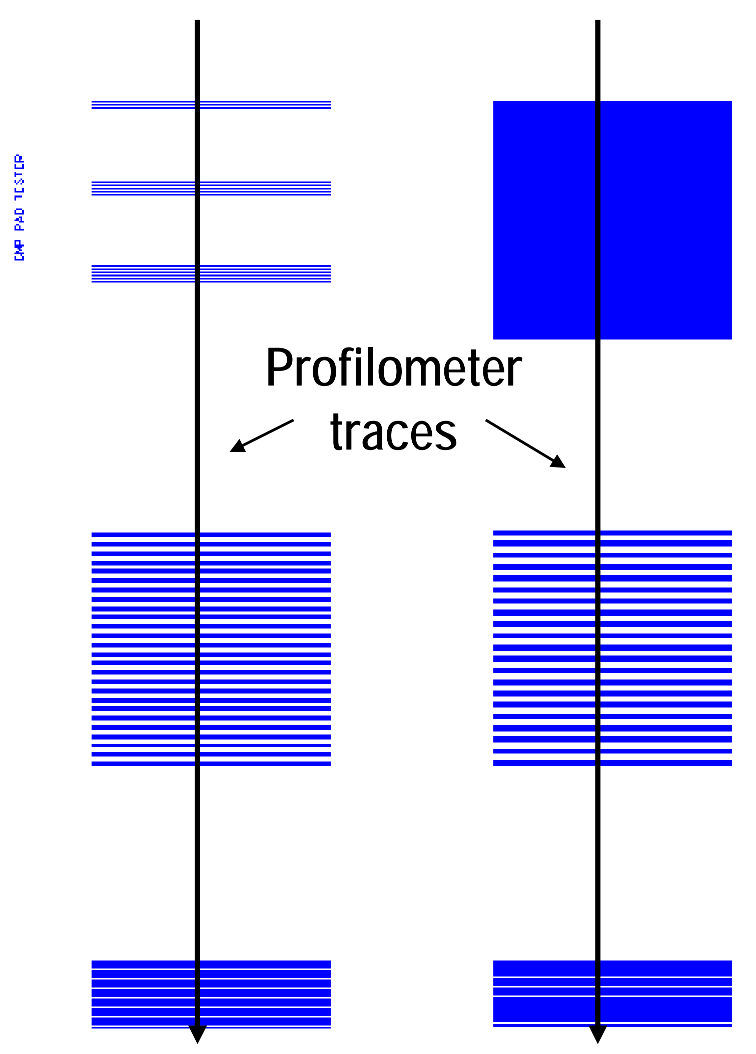
Get Topo vs. Pattern Density and Line Width

CMP Pads at Metal 1



Dense and Iso pad structures

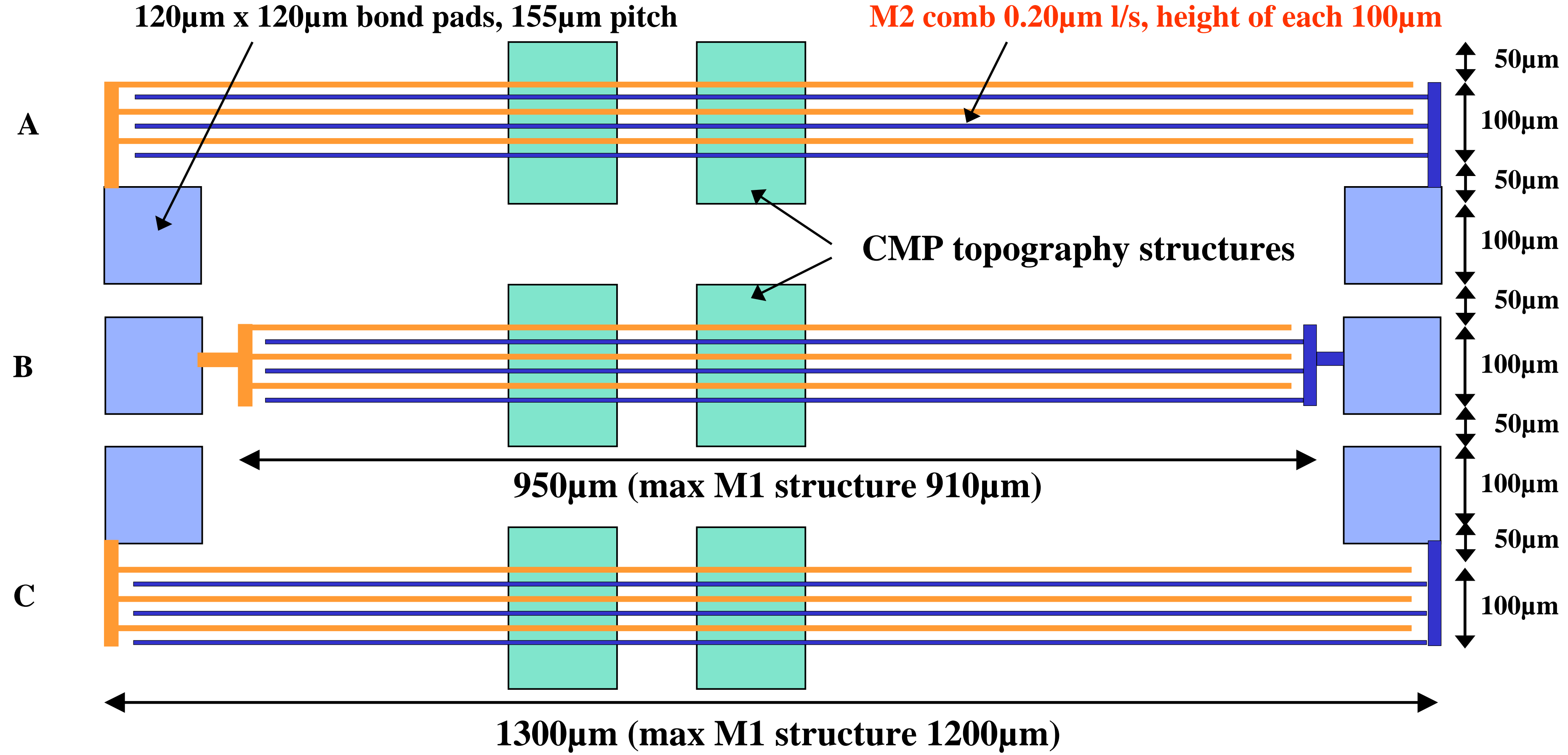
CMP Pad Testers



- 4 “pads” measured in 1 trace

Fang Test Structures

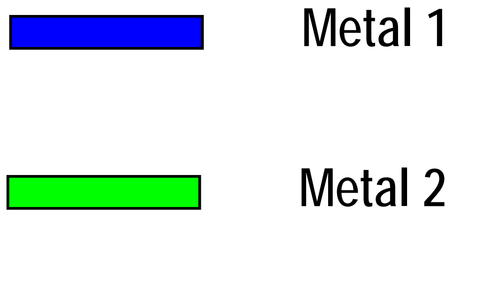
CMP Fang Tester Diagram



Use A, B, C for fang structures 1, 2 and 3
Use B for fang structure 4

CMP Fang Testers

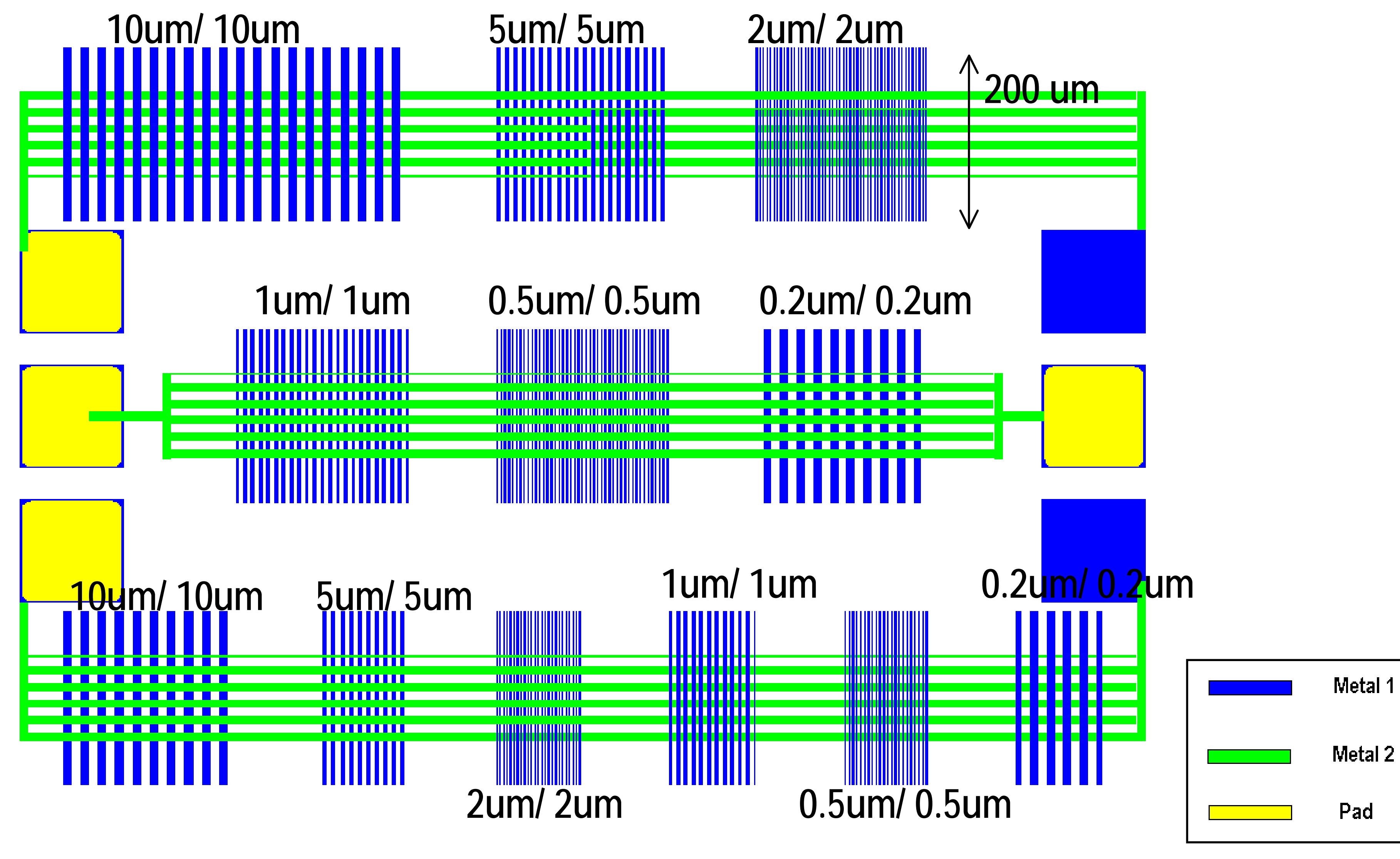
- Metal 2 COMBs over Metal Topography:
  - Metal 2 COMB dimensions: 0.2 µm line / 0.2 µm space
  - Metal 1 topography dimensions: see each page for detail.



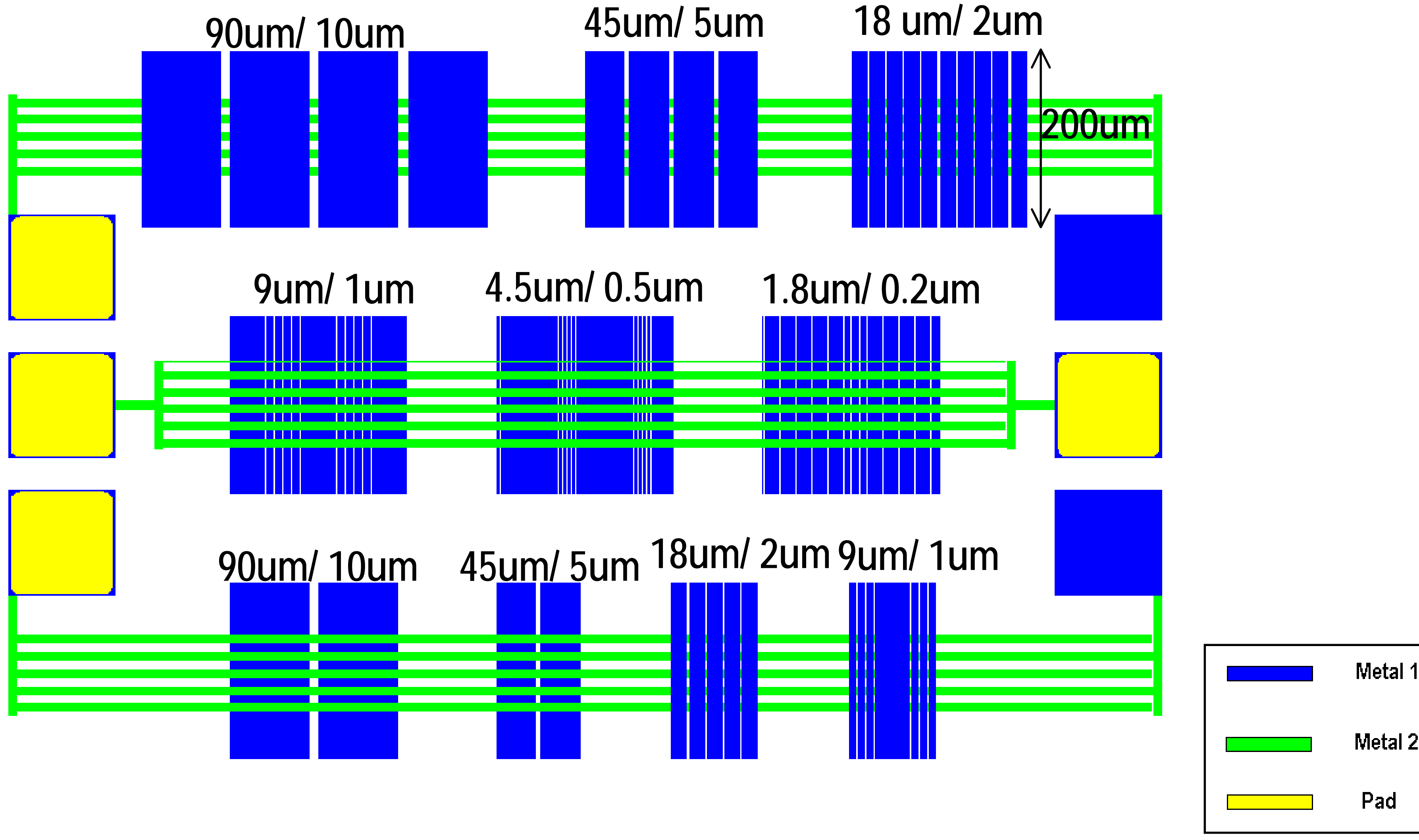
CMP Fang 1 Tester

The unit is um.

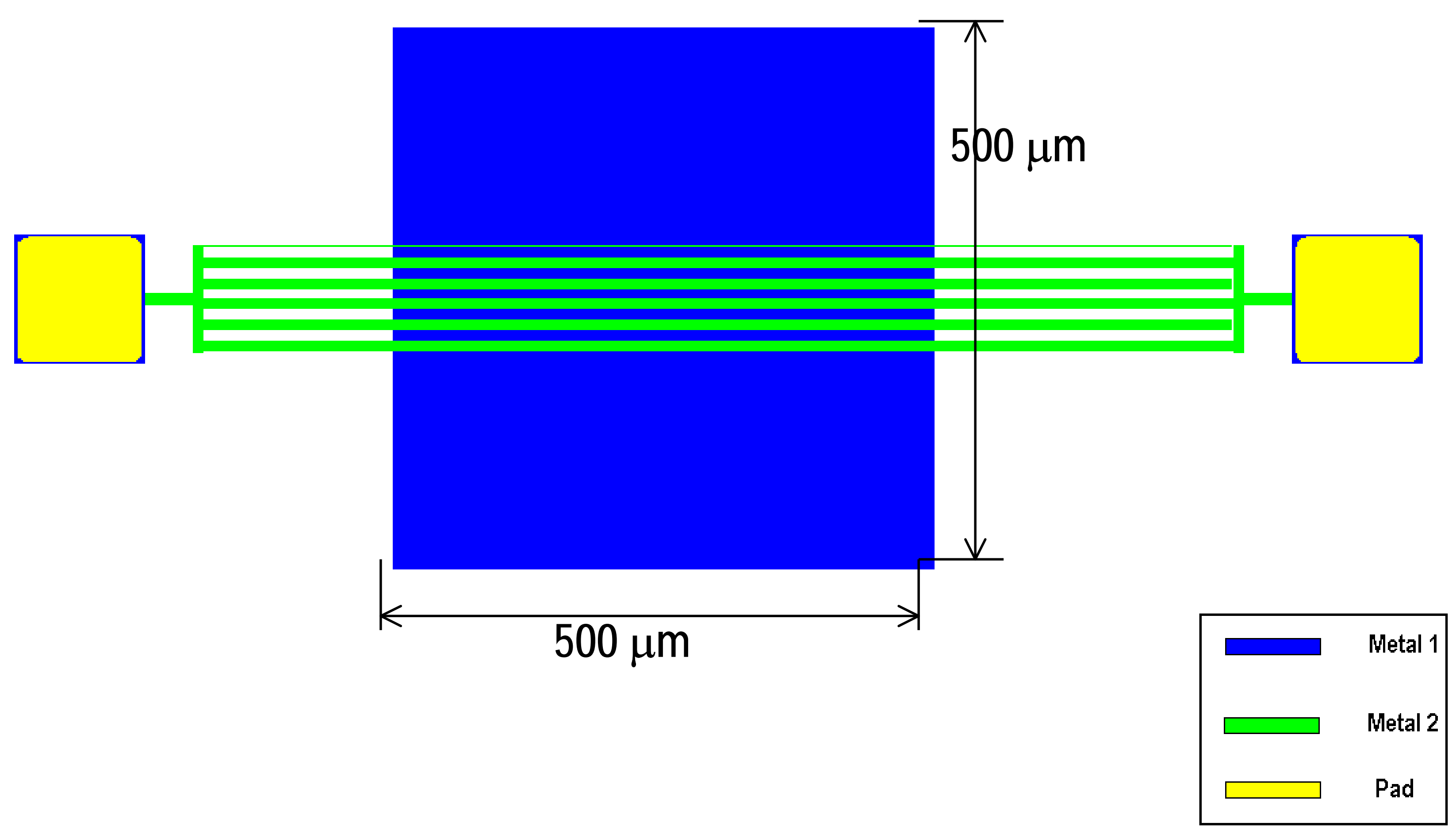
CMP Fang 2 Tester



CMP Fang 3 Tester

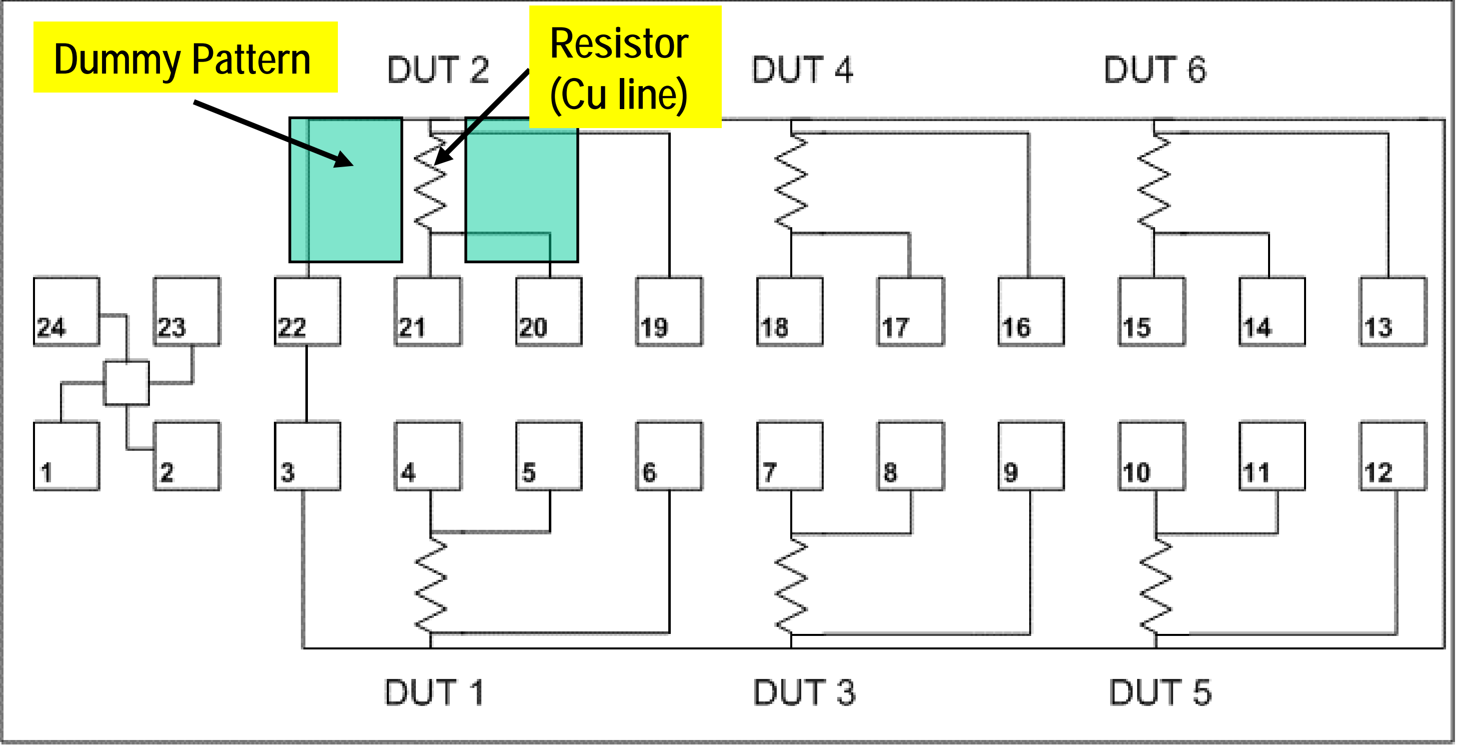


CMP Fang 4 Tester



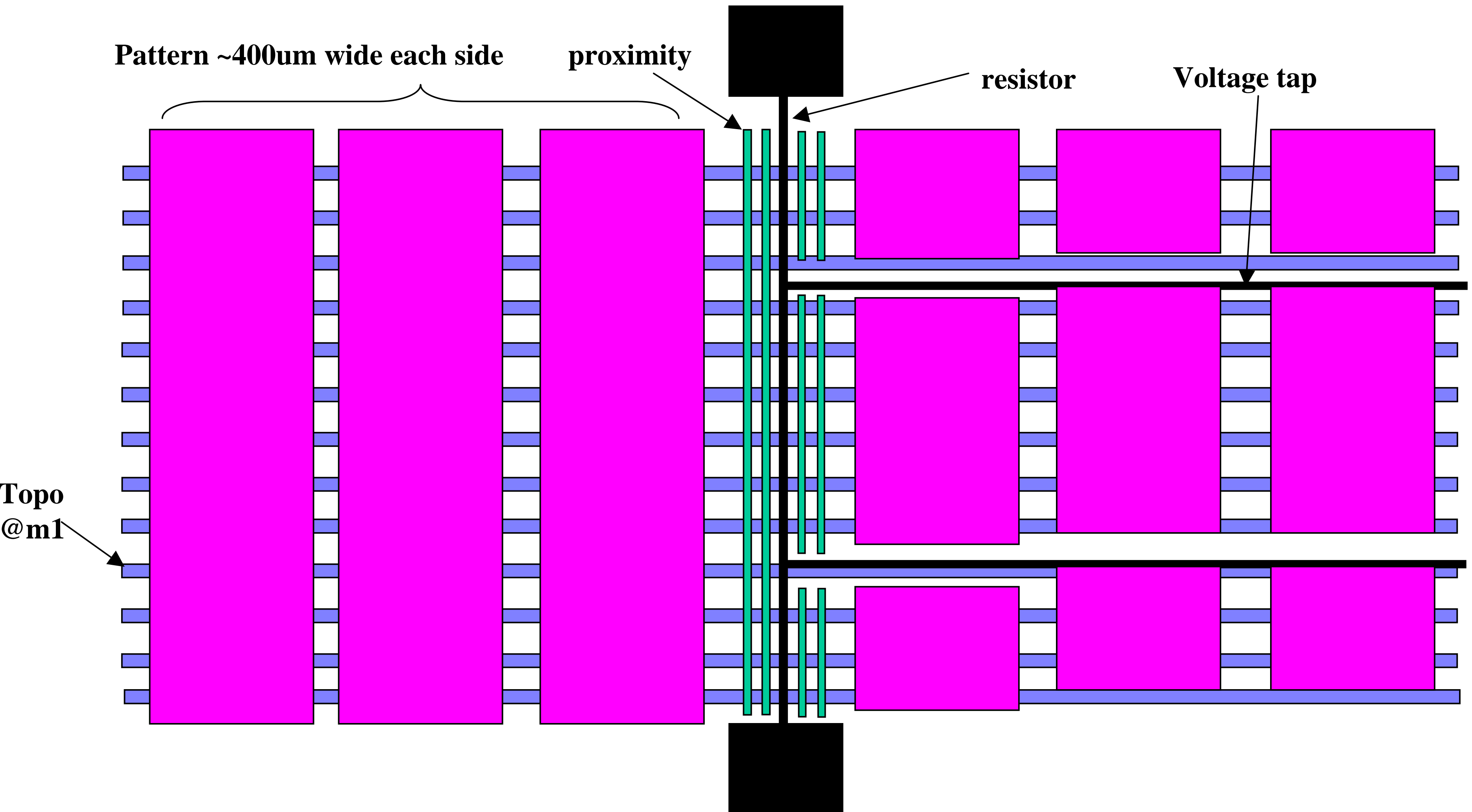
E-Test Structures

CMP Tester Layout



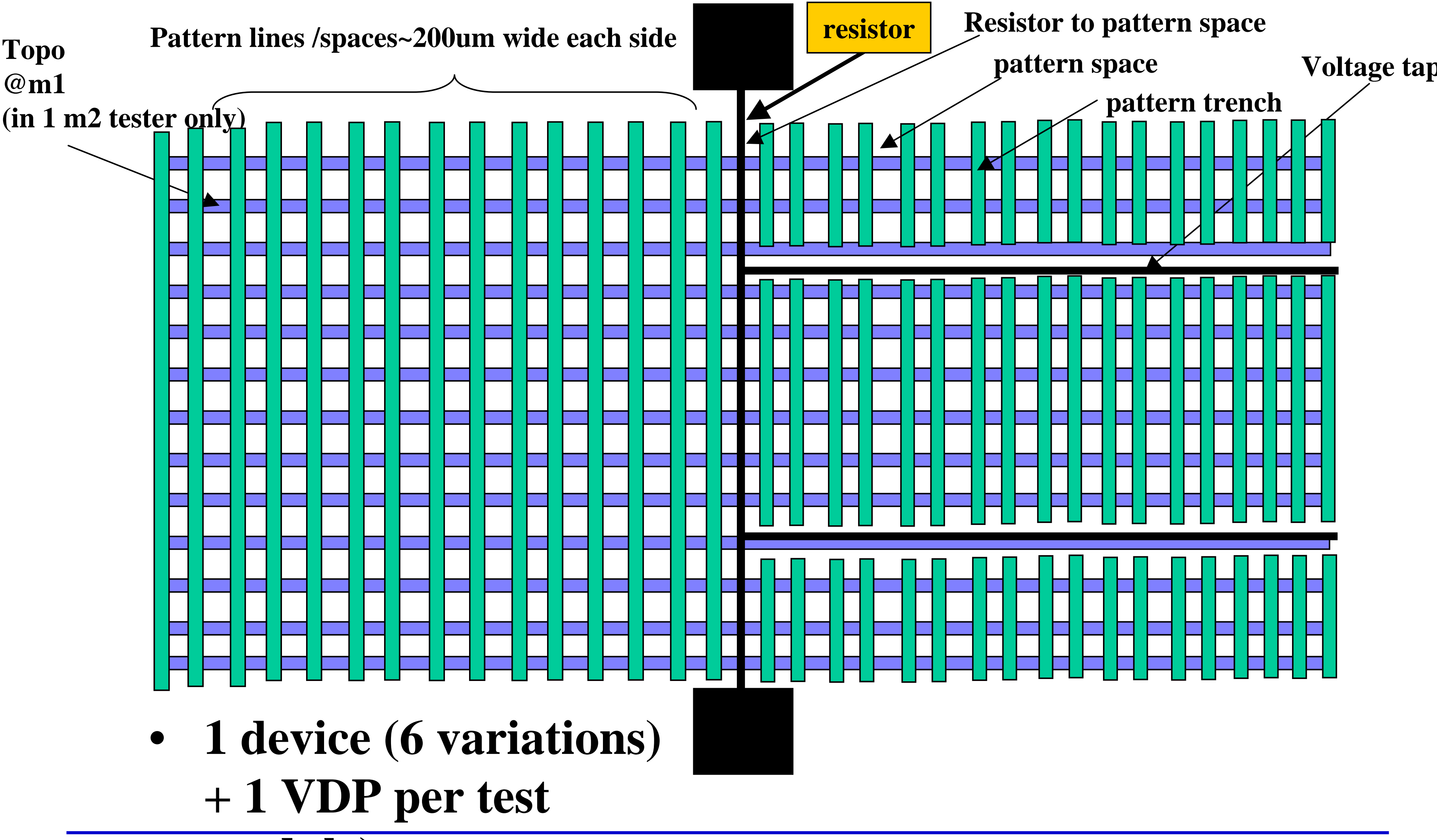
- Measure impact of dummy pattern on line resistance (dishing / erosion)
  - Each device (DUTs) has different dummy pattern or line width

ATR35 - CMP Resistance Testers



- 1 device (6 variations + 1 VDP per test module)

ATR35 - CMP Resistance Testers



- 1 device (6 variations) + 1 VDP per test module)

ATR35 - M1 CMP Resistance Testers

CMP_M1_a (replace CMP_m1_top section)								
length lines = 750um			width in um	width in um	width in um	width in um	width in um	width in um
DR	Description	VDP	DUT1	DUT2	DUT3	DUT4	DUT5	DUT6
1	Resistor line-width		0.2	0.2	0.2	0.2	0.2	0.2
2	Resistor to pattern line spacing		0.2	0.2	0.2	0.2	0.2	0.2
3	Pattern line-width		1	0.2	10	50	200	90
4	Pattern spacing		0	0.2	10	0	0	10
5	# pattern l/s on each side of resistor		1	500	10	1	1	2
6	total width (um)		2.6	401	401	101	401	401
7	resistor line length		600	600	600	600	600	600
8	pattern density		<1	50.00	50.00	99.00	99+	90.00
9	VDP line width	10	iso		fang	dishing	dishing	
CMP_M1_b (replace CMP_M3_ top section)								
DR	Description	VDP	DUT1	DUT2	DUT3	DUT4	DUT5	DUT6
1	Resistor line-width		10	10	10	10	10	10
2	Resistor to pattern line spacing			0.2	10	0.2	0.2	10
3	Pattern line-width			0.2	10	10	90	90
4	Pattern spacing			0.2	10	10	10	10
5	# pattern l/s on each side of resistor		0	488	9	10	2	2
6	total width (um)		10	401	390	410	410	430
7	resistor line length		600	600	600	600	600	600
8	pattern density		<1	50.00	50.00	50.00	90.00	90.00
9	VDP line width	50	iso		fang		dishing	dishing

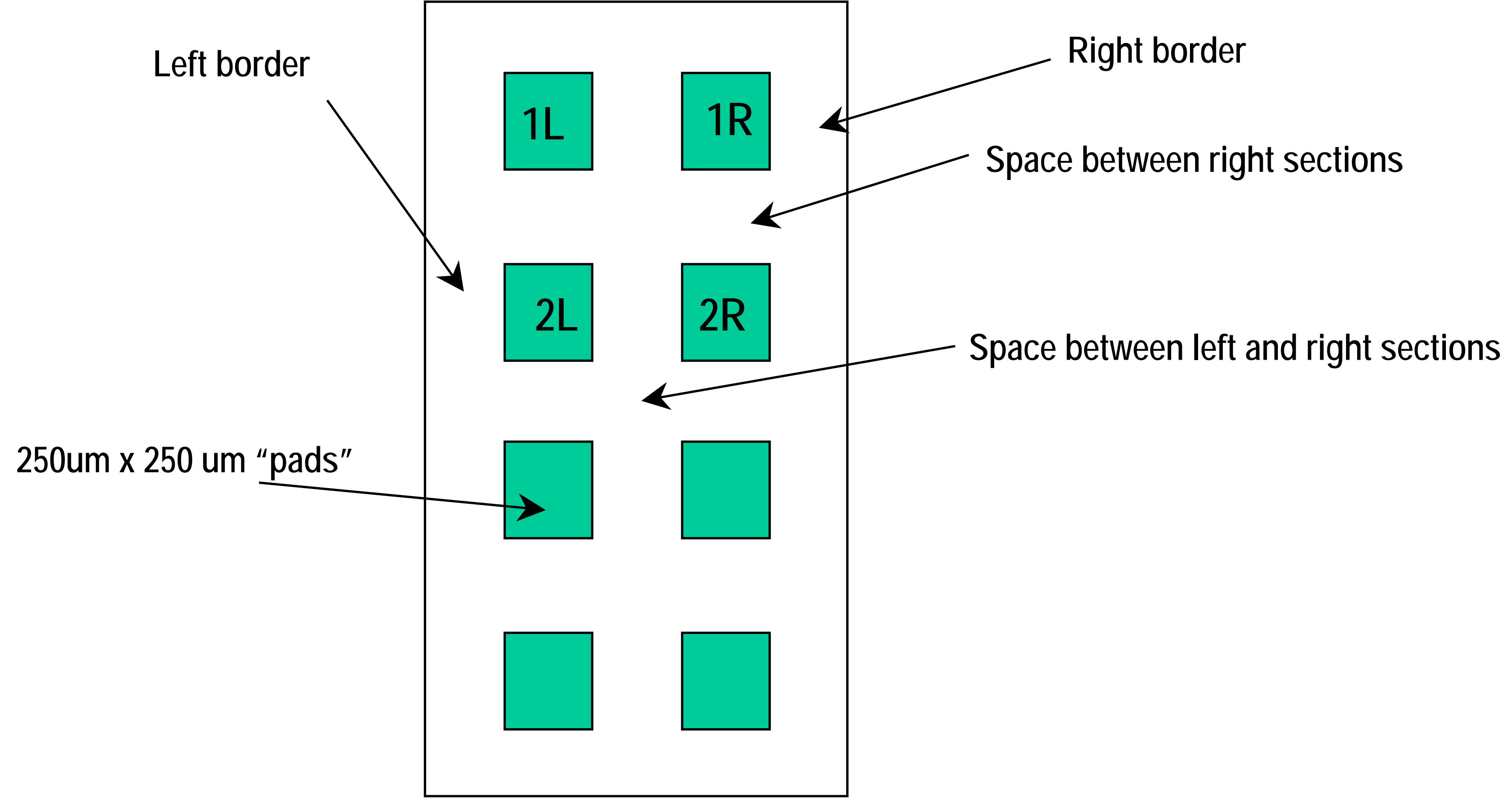
ATR35 M2 CMP Resistance Testers

CMP_M2_a (replace CMP_m2_top section)								
length lines = 750um			width in um	width in um	width in um	width in um	width in um	width in um
DR	Description	VDP	**DUT1**	DUT2	DUT3	**DUT4**	**DUT5**	DUT6
1	Resistor line-width		**0.2**	10	**0.2**	**10**	**0.2**	10
2	Resistor to pattern line spacing			0.2	**4.9**	10	**0.2**	0.2
3	Pattern line-width			0.2	**10**	**10**	**200**	90
4	Pattern spacing			0.2	**10**	**10**	**0**	10
5	# pattern l/s on each side of resistor		**0**	488	**10**	**9**	**1**	2
6	total width (um)		**0.2**	**401**	**410**	**390**	**401**	**410**
7	resistor line length		**600**	600	**600**	**600**	**600**	600
8	pattern density		**<1**	<1	**50.00**	50.00	**98.00**	**90.00**
9	VDP line width	10	**iso**	**iso**	**fang**	**fang**	**dishing**	**dishing**

CMP_M2_b - with underlying topo (replace CMP_M2 in bottom section)								
DR	Description		DUT1	DUT2	DUT3	DUT4	DUT5	DUT6
1	Resistor line-width		**0.2**	**0.2**	**0.2**	10	10	10
2	Resistor to pattern line spacing		**0.2**	**0.2**	**0.2**	0.2	0.2	0.2
3	Pattern line-width		**0.2**	**0.2**	**0.2**	0.2	0.2	0.2
4	Pattern spacing		**0.2**	**0.2**	**0.2**	0.2	0.2	0.2
5	# pattern l/s on each side of resistor		**500**	**500**	**500**	488	488	488
6	total width (um)		**401**	**401**	**401**	**401**	**401**	**401**
7	resistor line length		**600**	**600**	**600**	600	600	600
8	pattern density		**50.00**	**50.00**	**50.00**	**50.00**	**50.00**	**50.00**
9	M1 topo (l/s) - horizontal		.2/.2	10/10	90/10	.2/.2	10/10	90/10
10	VDP	50						

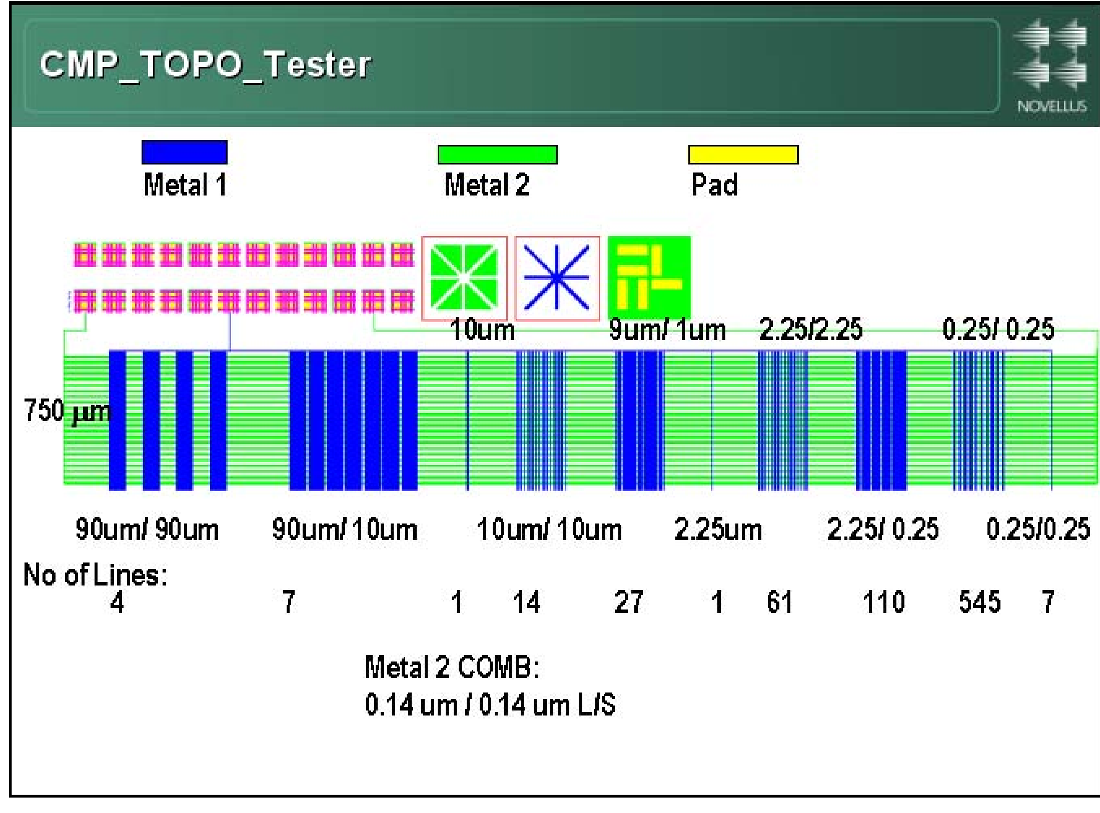
CMP Pad Tester Diagram - different pattern in each "pad"

- Horizontal trenches spaces in each section

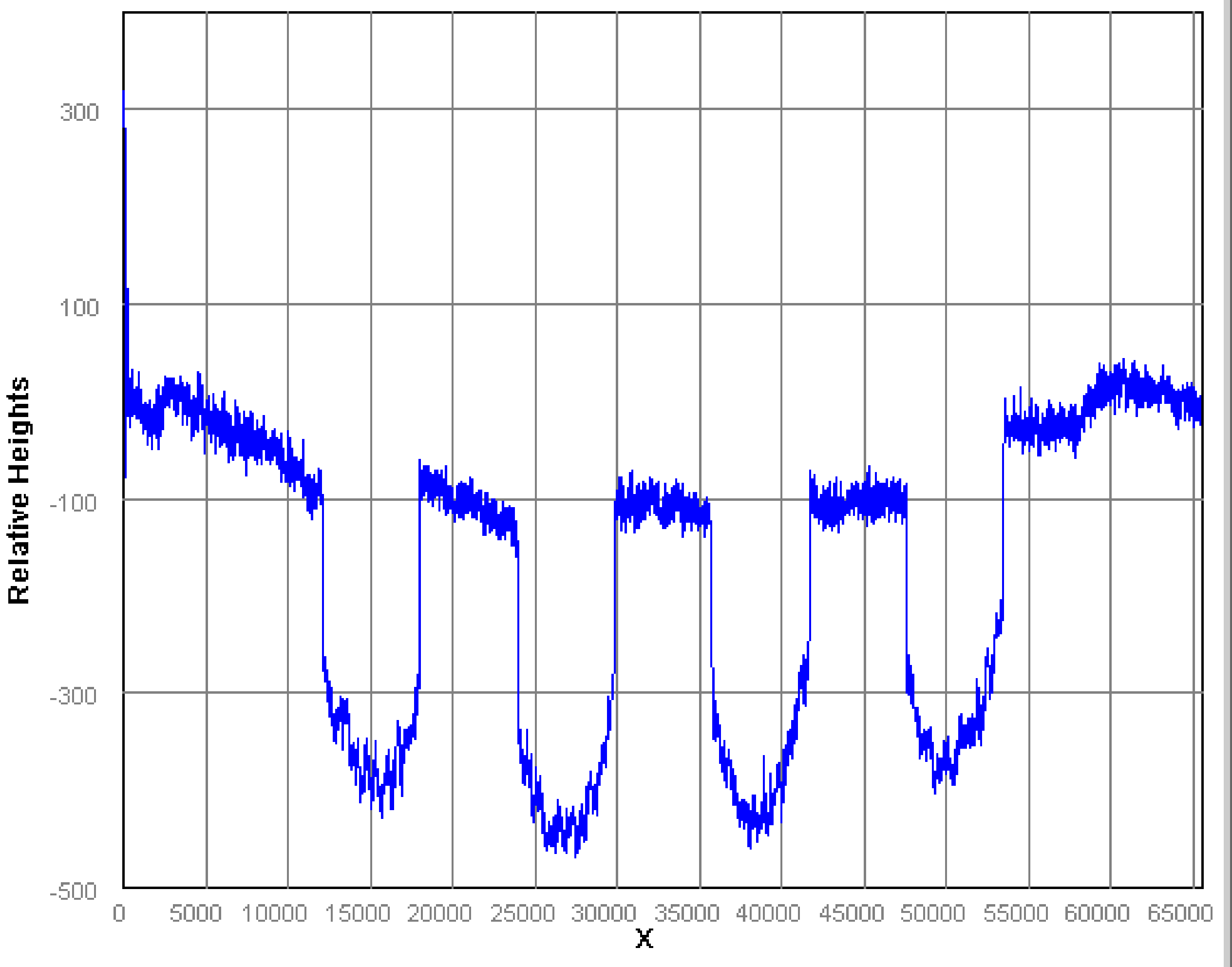


Recommended ATR35 Structure

- **The structure on ATR35 which most closely matches the 100/100 structure on Sematech is the 90/90 structure**
  - Refer to slide 13



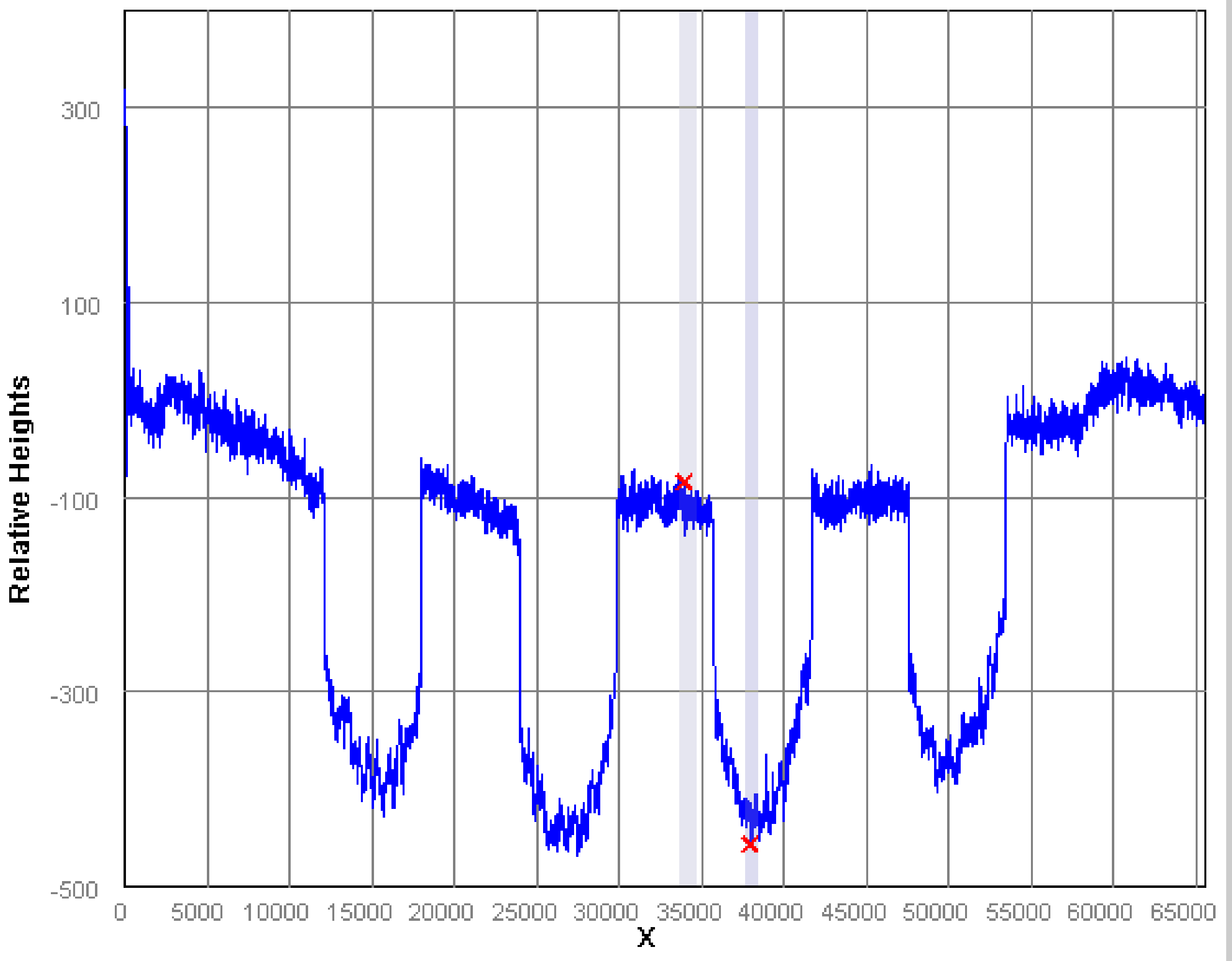
CMP_TOPO_Tester 90um/90um Line Profile



SCAN INFO	
Recipe	
Samples	9363
# of Features	2

RESULT	
Dishing	374.0053
Erosion	87.2454

CMP_TOPO_Tester 90um/90um Line Profile

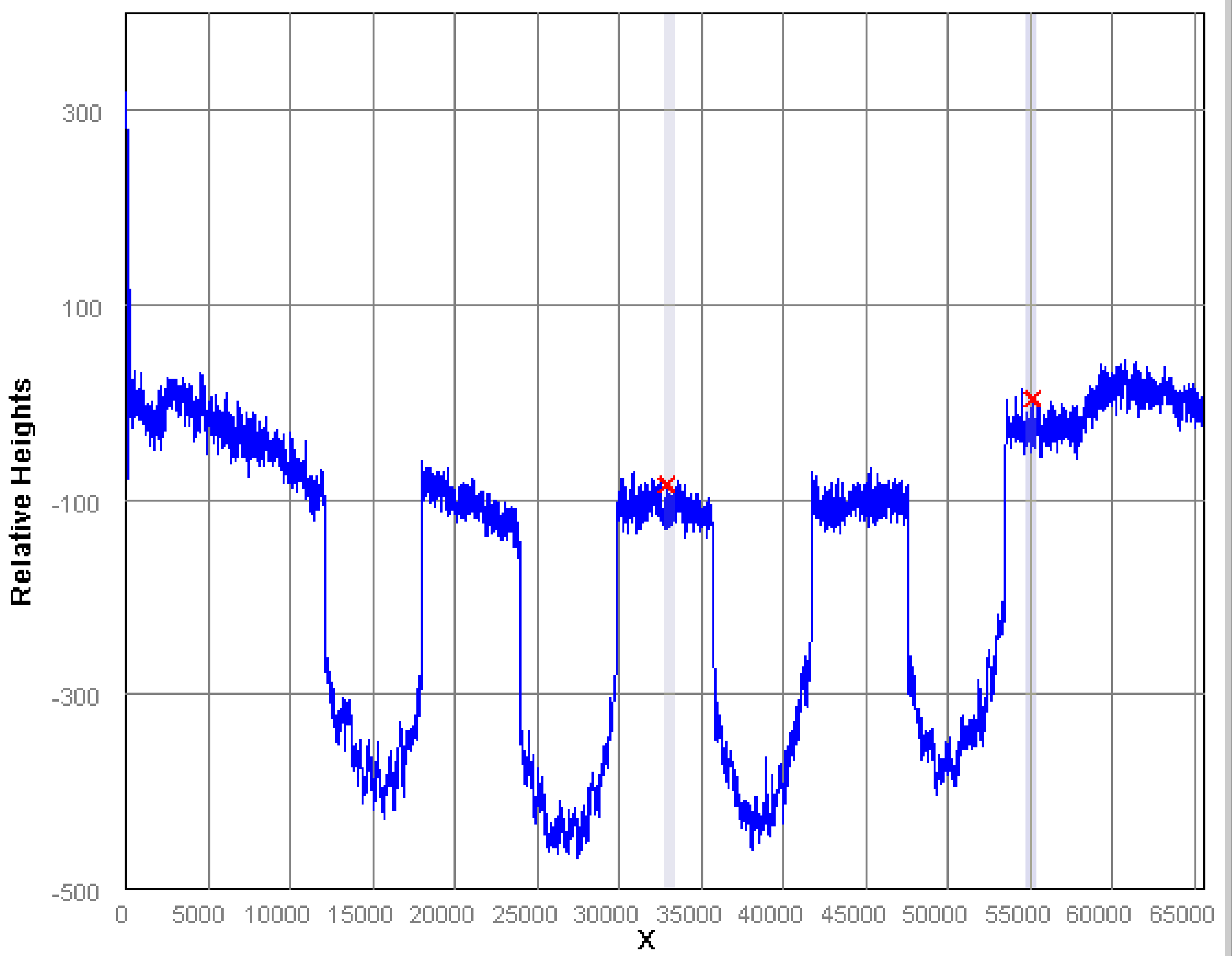


SCAN INFO	
Recipe	
Samples	9363
# of Features	1

LEVEL	
Slope	-1.2758
LL	528.508
LR	1189.143
(LL-LR)	660.635
RL	64345.857
RR	65006.492
(RL-RR)	660.635

DISHING	
Dishing	371.6104
LL	33699.909
LR	34765.518
(LL-LR)	1065.61
RL	37695.945
RR	38495.152
(RL-RR)	799.207

CMP_TOPO_Tester 90um/90um Line Profile



SCAN INFO	
Recipe	
Samples	9363
# of Features	1

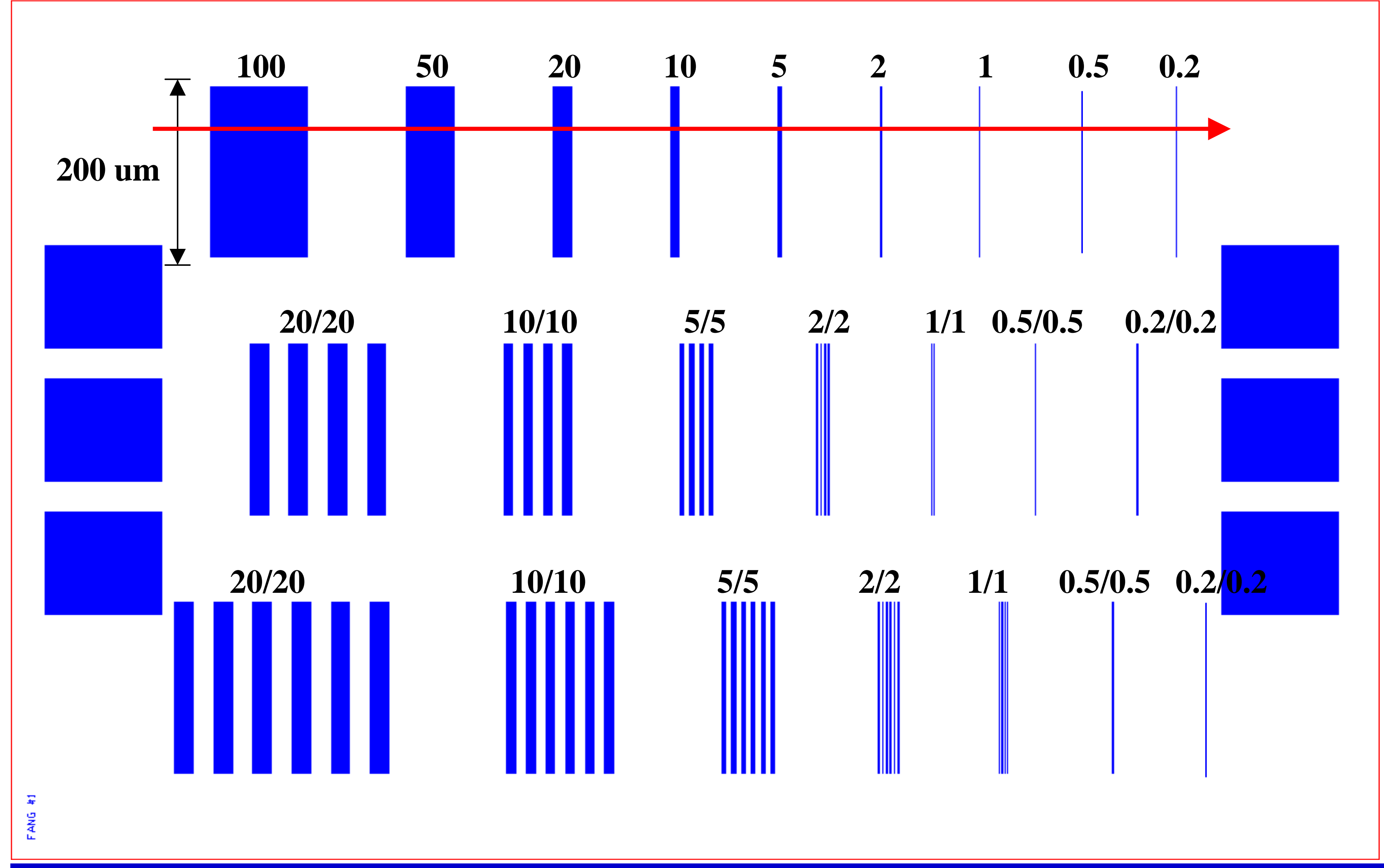
LEVEL	
Slope	-1.276
LL	528.508
LR	1189.143
(LL-LR)	660.635
RL	64345.857
RR	65006.492
(RL-RR)	660.635

EROSION	
Erosion	87.245
LL	32832.13
LR	33478.432
(LL-LR)	646.302
RL	54806.391
RR	55452.692
(RL-RR)	646.302

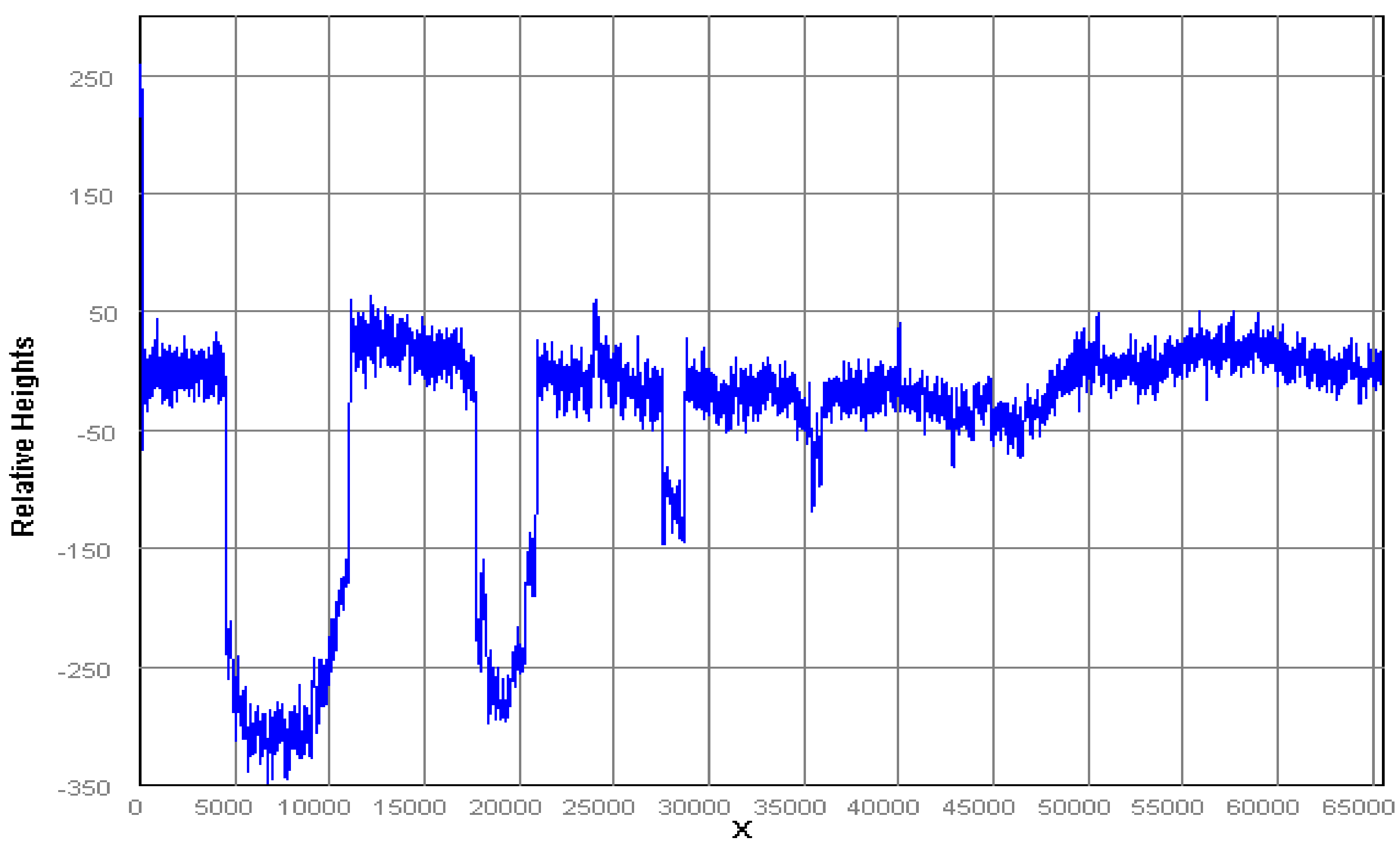
ATR35 Summary

- Design rules at 140nm and 90nm
- Multiple CMP test physical and electrical test structures

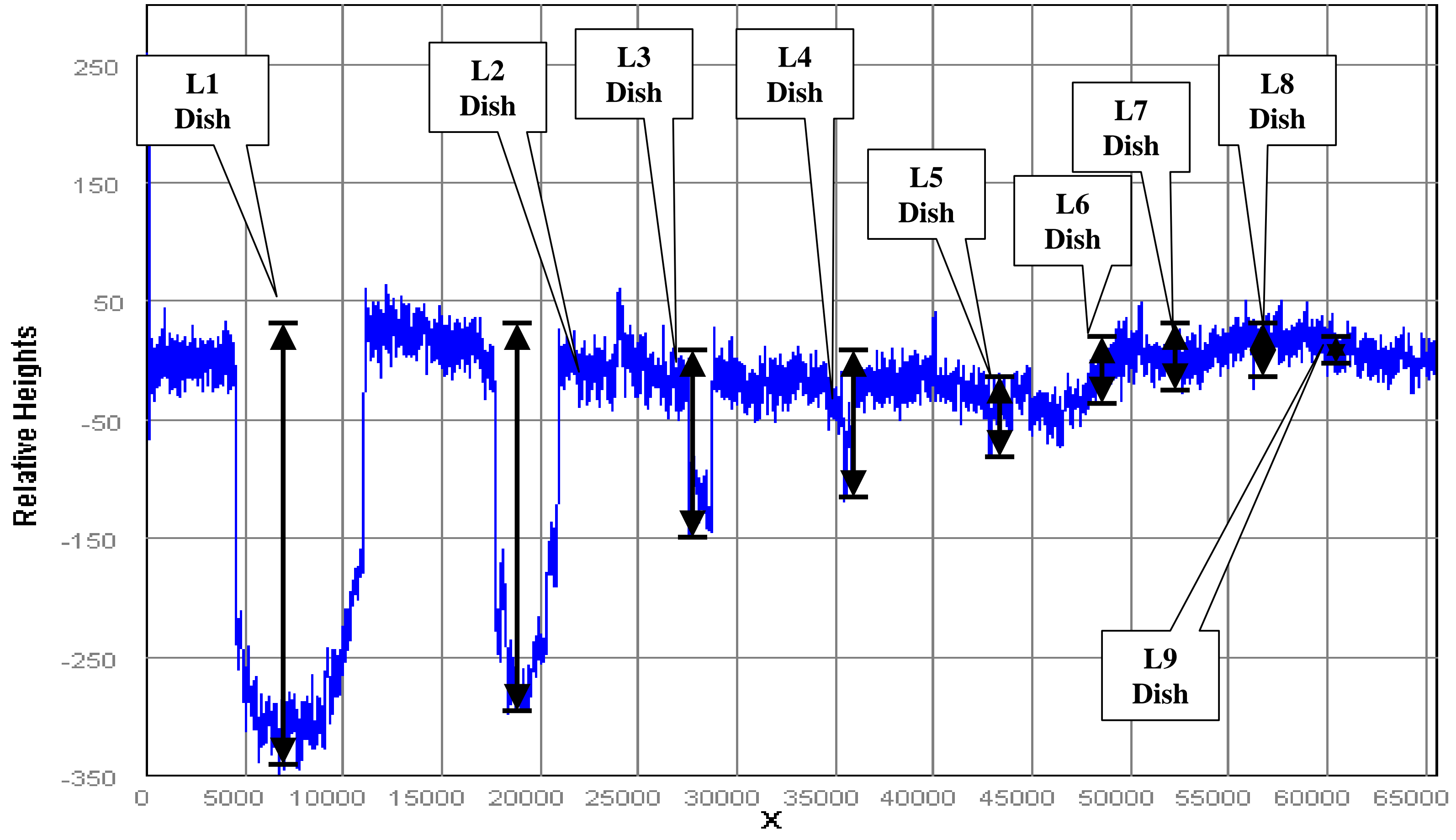
CMP_FANG1 Die Floor Plan



CMP_FANG1 Row 1 Line Profile

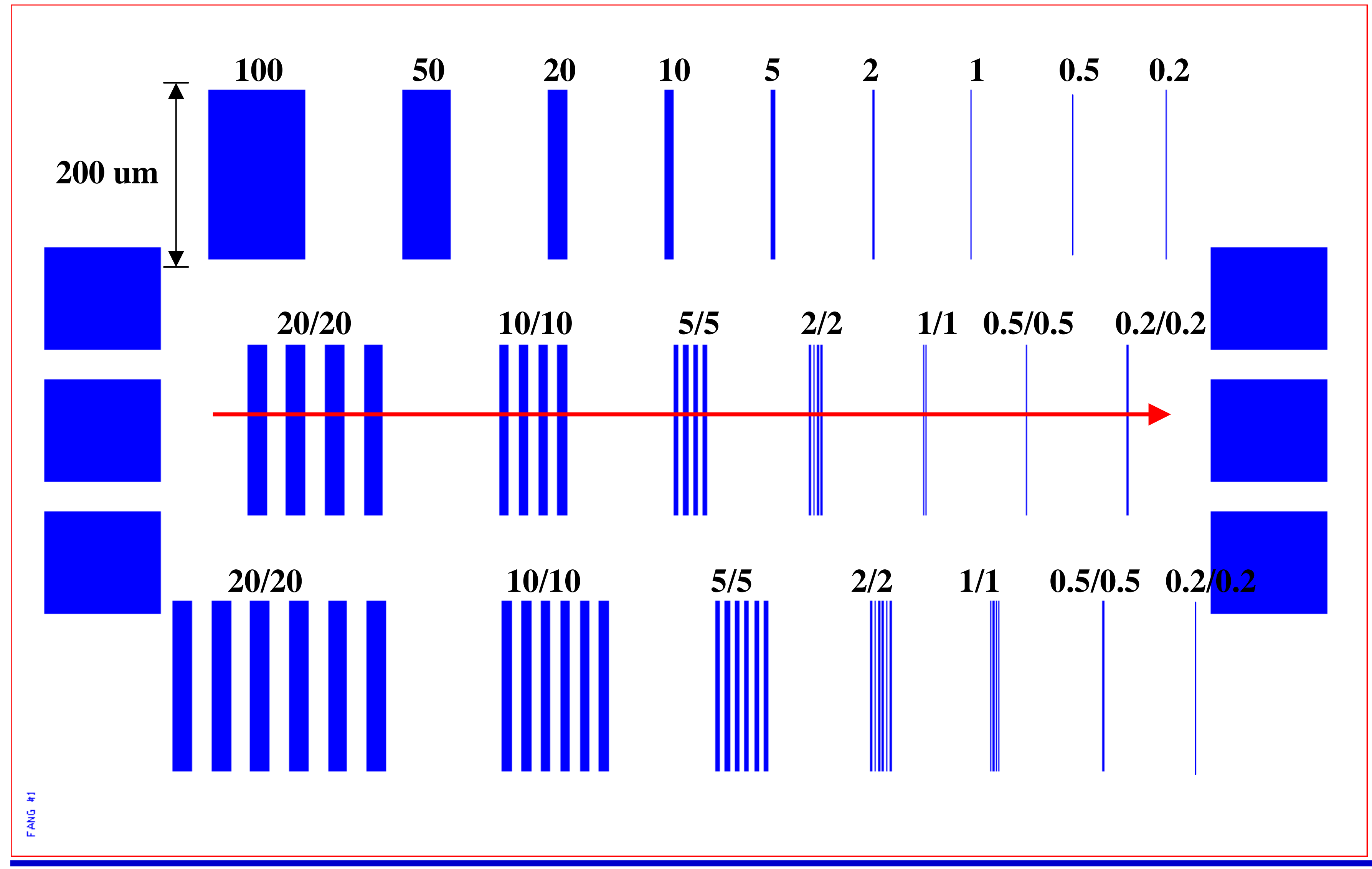


CMP_FANG1 Row 1 Line Profile

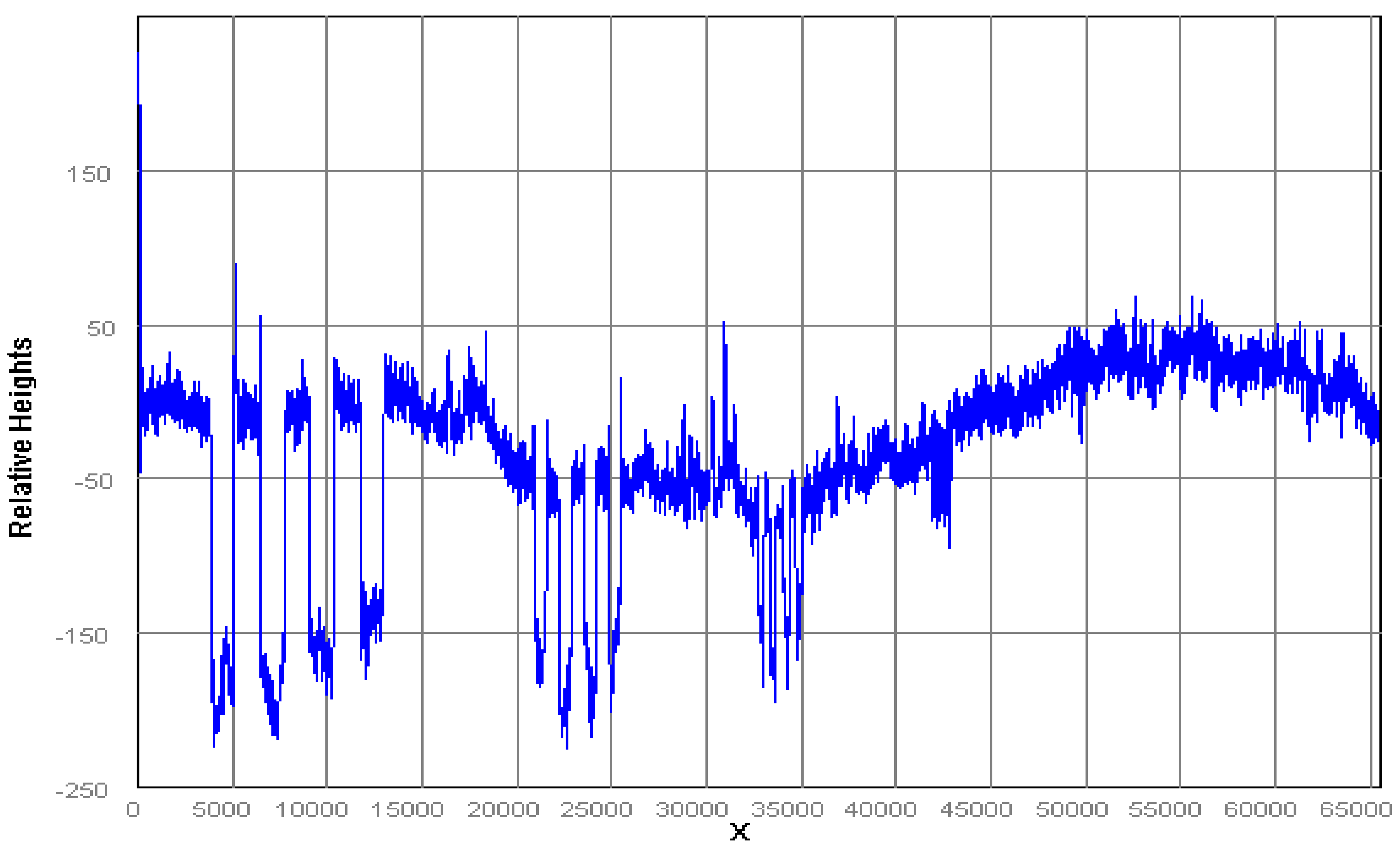


L1 Dish (Å)	L2 Dish (Å)	L3 Dish (Å)	L4 Dish (Å)	L5 Dish (Å)	L6 Dish (Å)	L7 Dish (Å)	L8 Dish (Å)	L9 Dish (Å)
370	309	148	90	67	48	36	23	6

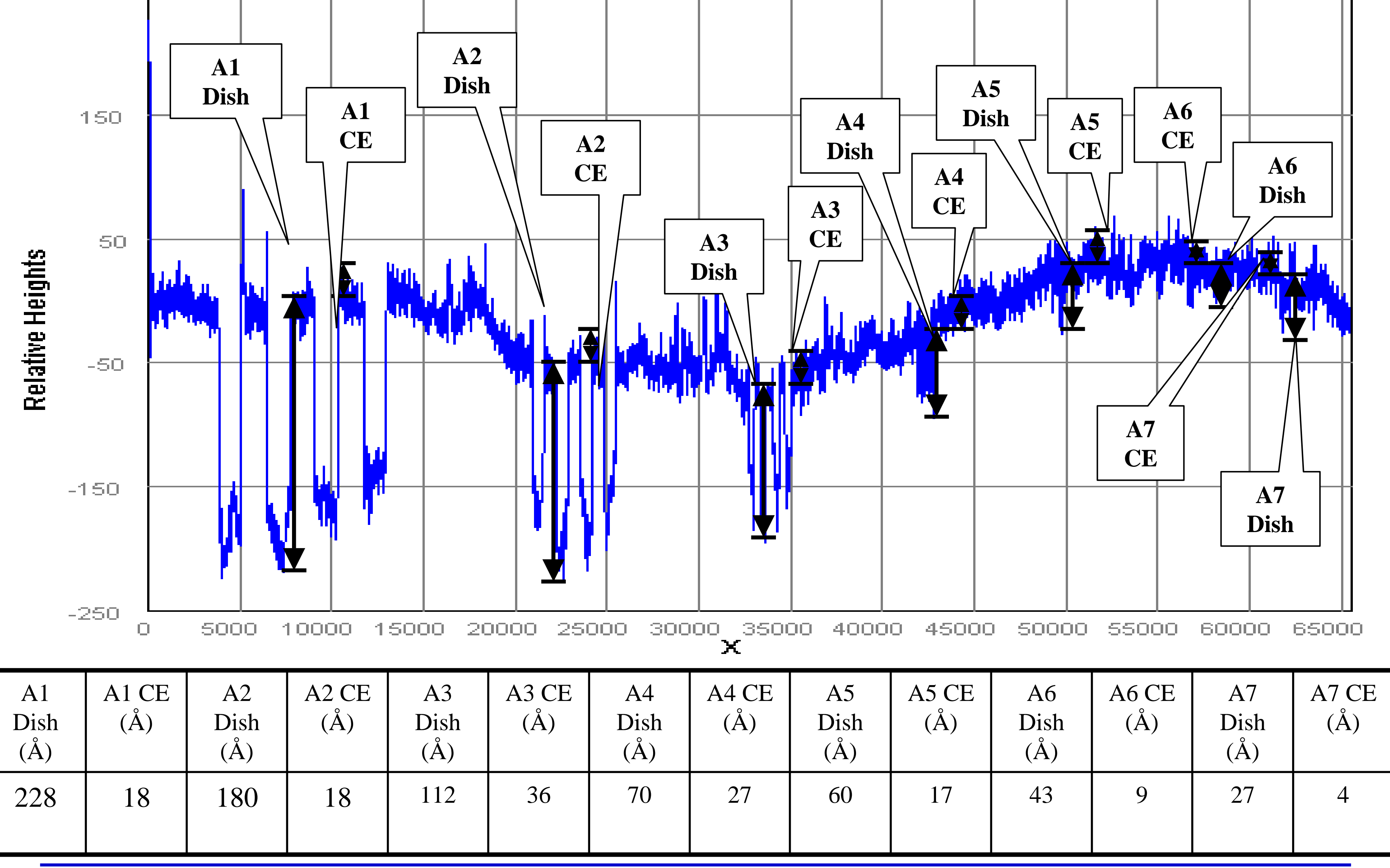
CMP_FANG1 Die Floor Plan



CMP_FANG1 Row 2 Line Profile

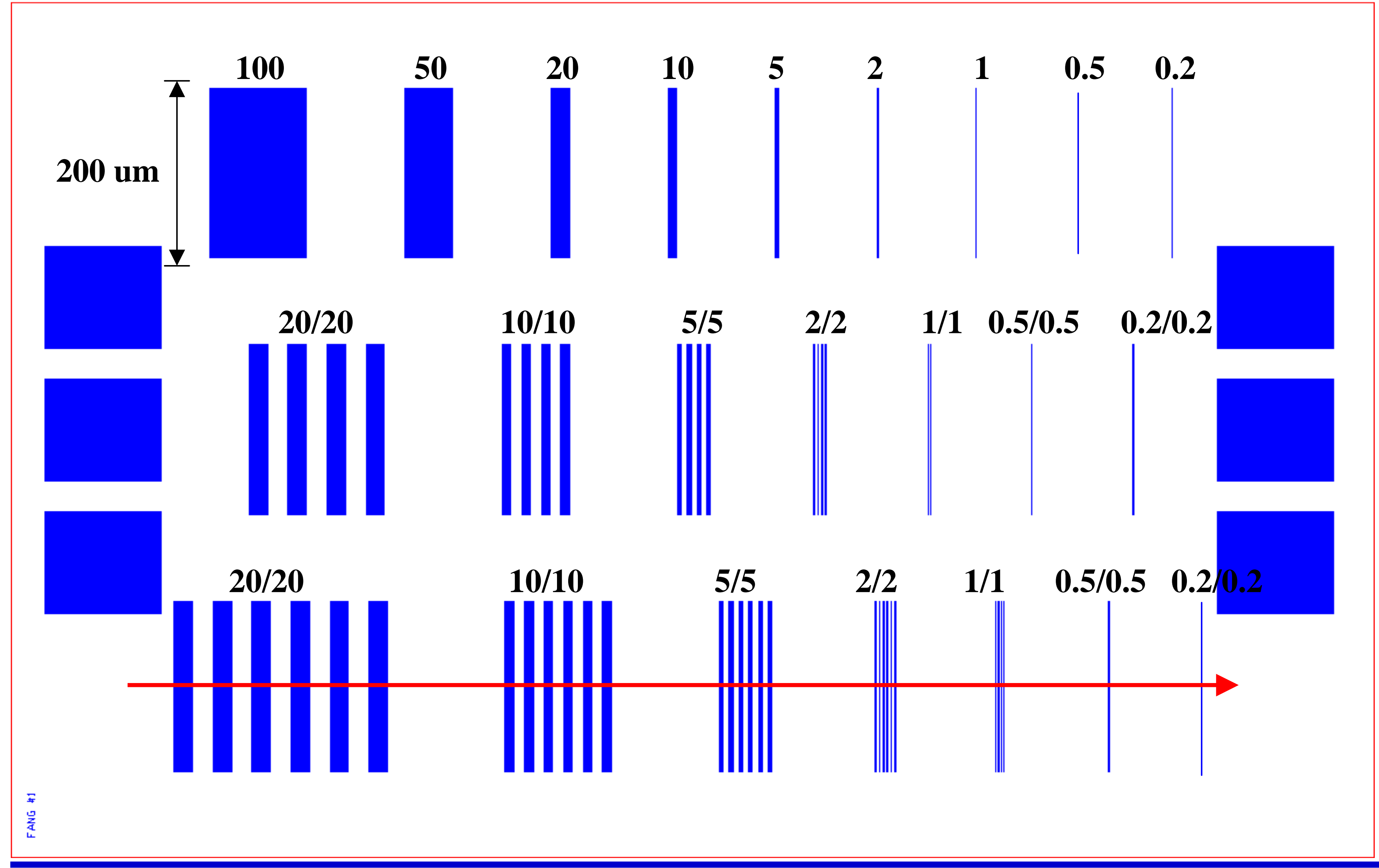


CMP_FANG1 Row 2 Line Profile

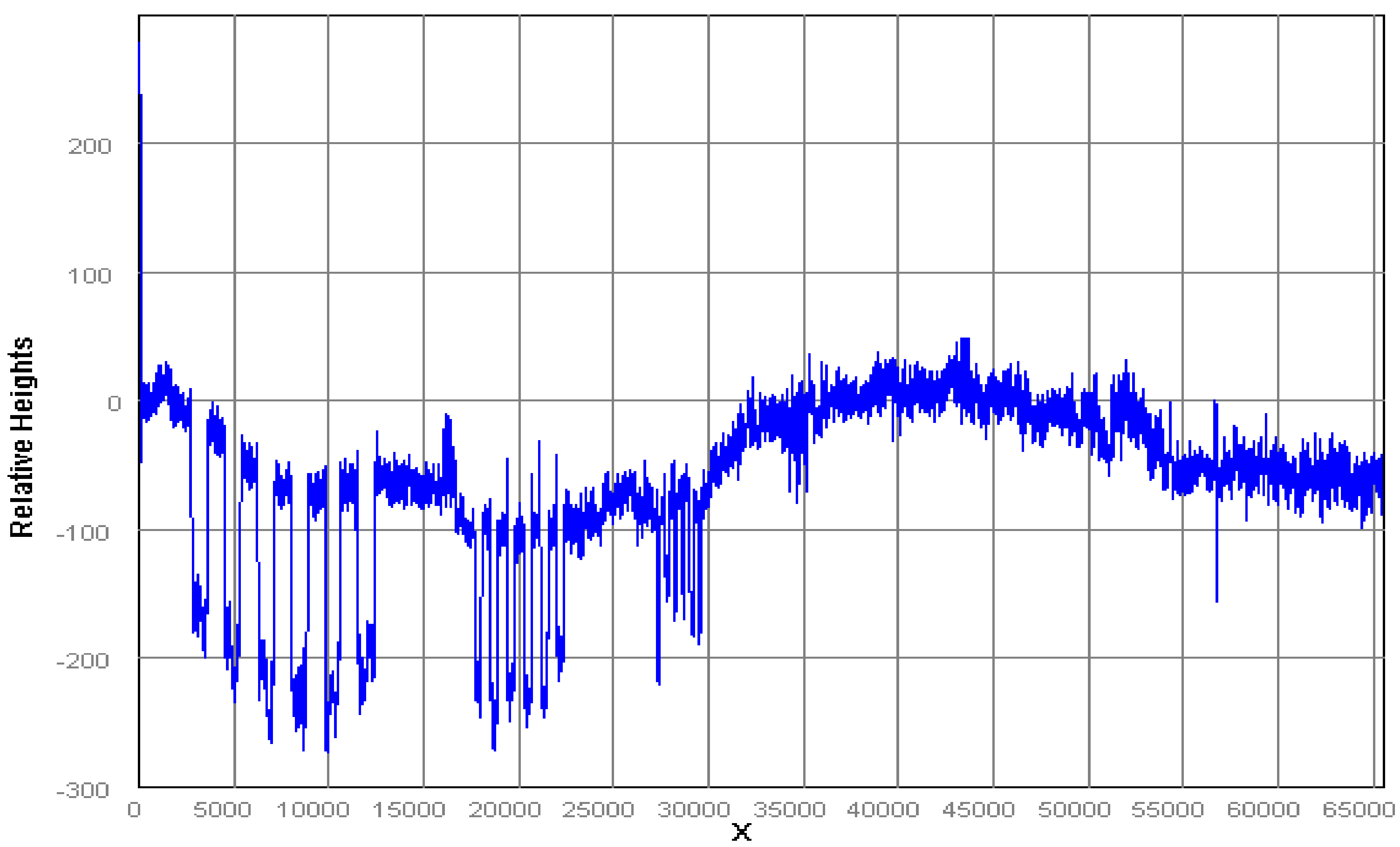


A1 Dish (Å)	A1 CE (Å)	A2 Dish (Å)	A2 CE (Å)	A3 Dish (Å)	A3 CE (Å)	A4 Dish (Å)	A4 CE (Å)	A5 Dish (Å)	A5 CE (Å)	A6 Dish (Å)	A6 CE (Å)	A7 Dish (Å)	A7 CE (Å)
228	18	180	18	112	36	70	27	60	17	43	9	27	4

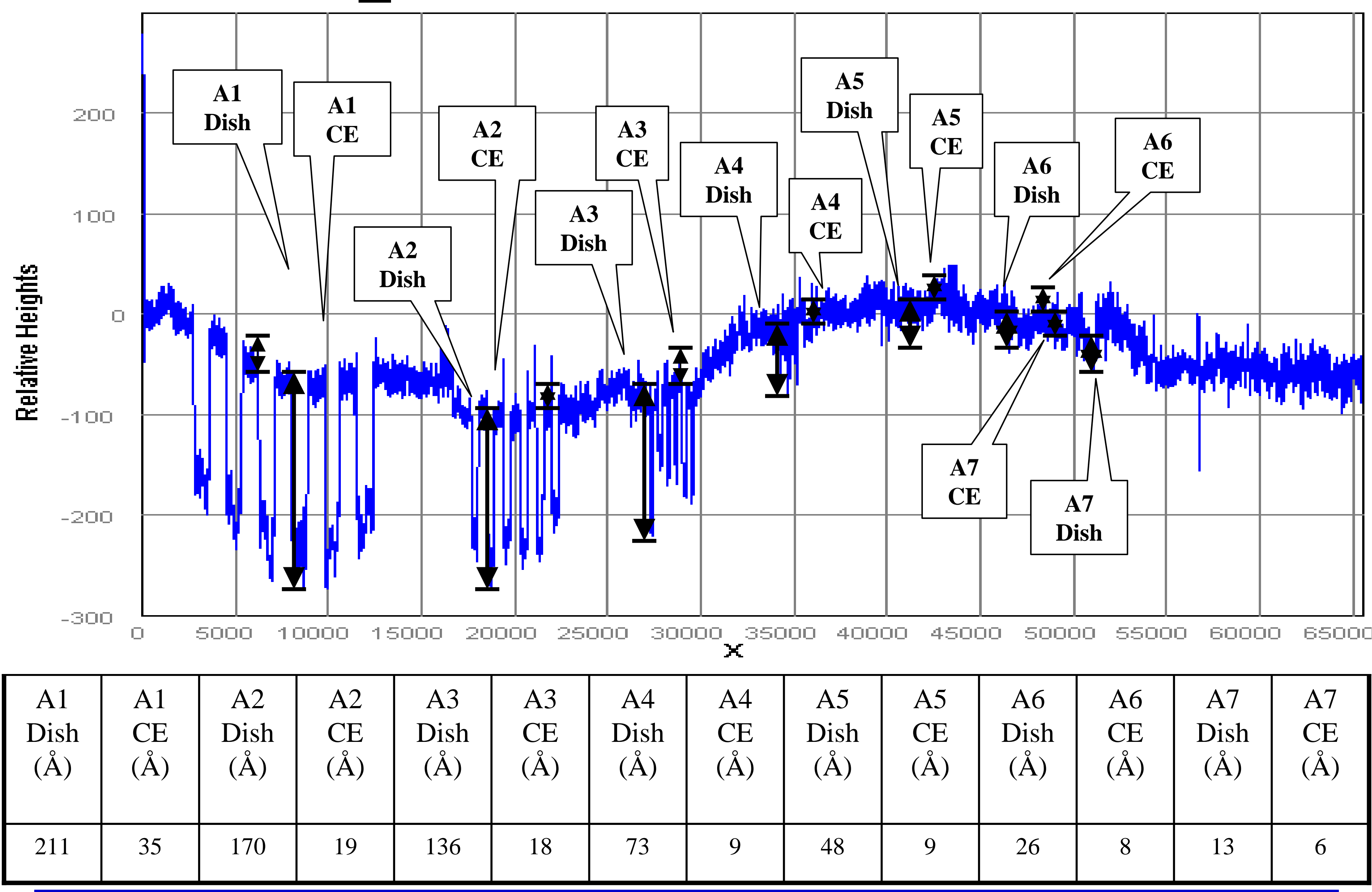
CMP_FANG1 Die Floor Plan



CMP_FANG1 Row 3 Line Profile

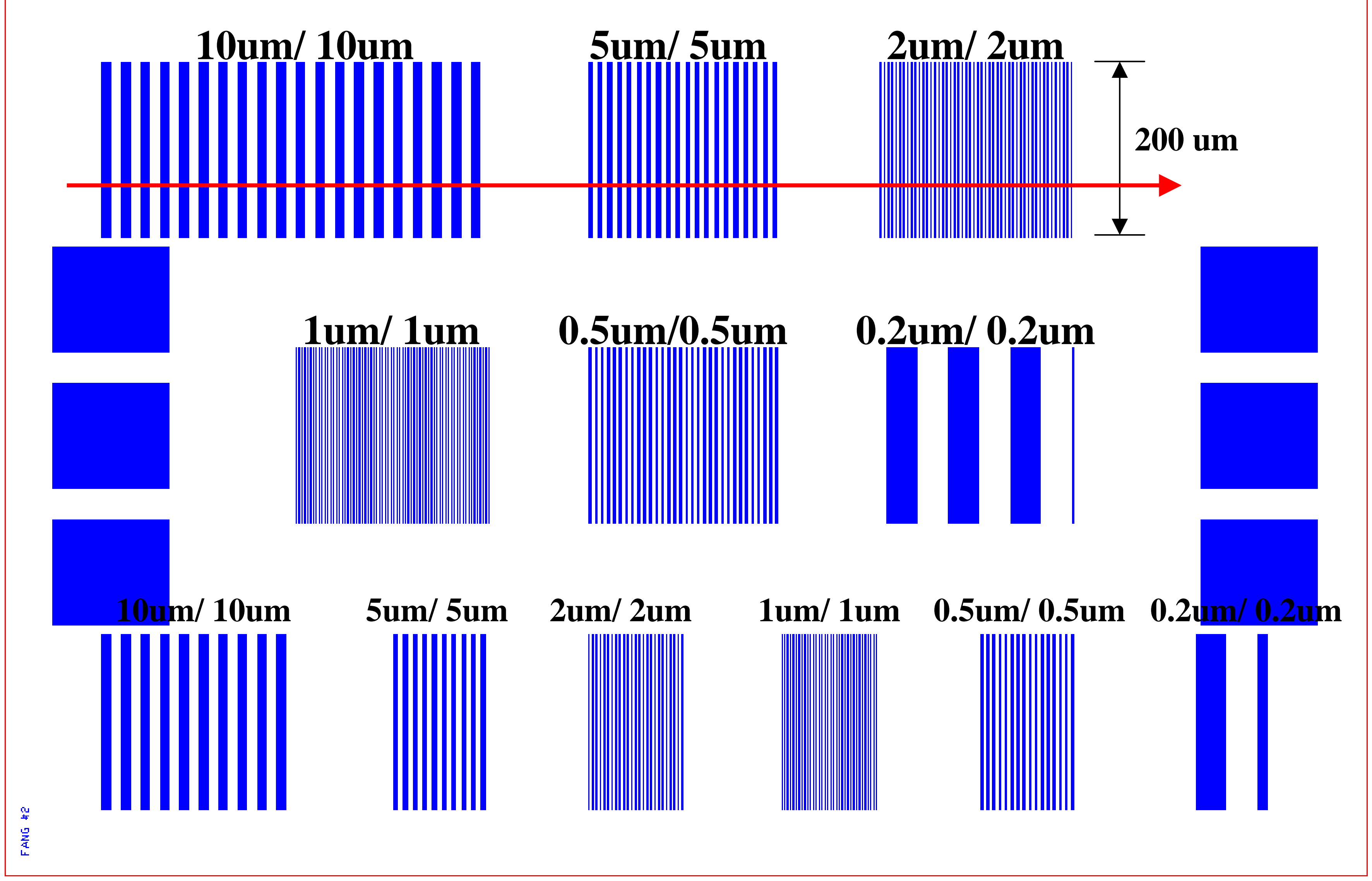


CMP_FANG1 Row 3 Line Profile

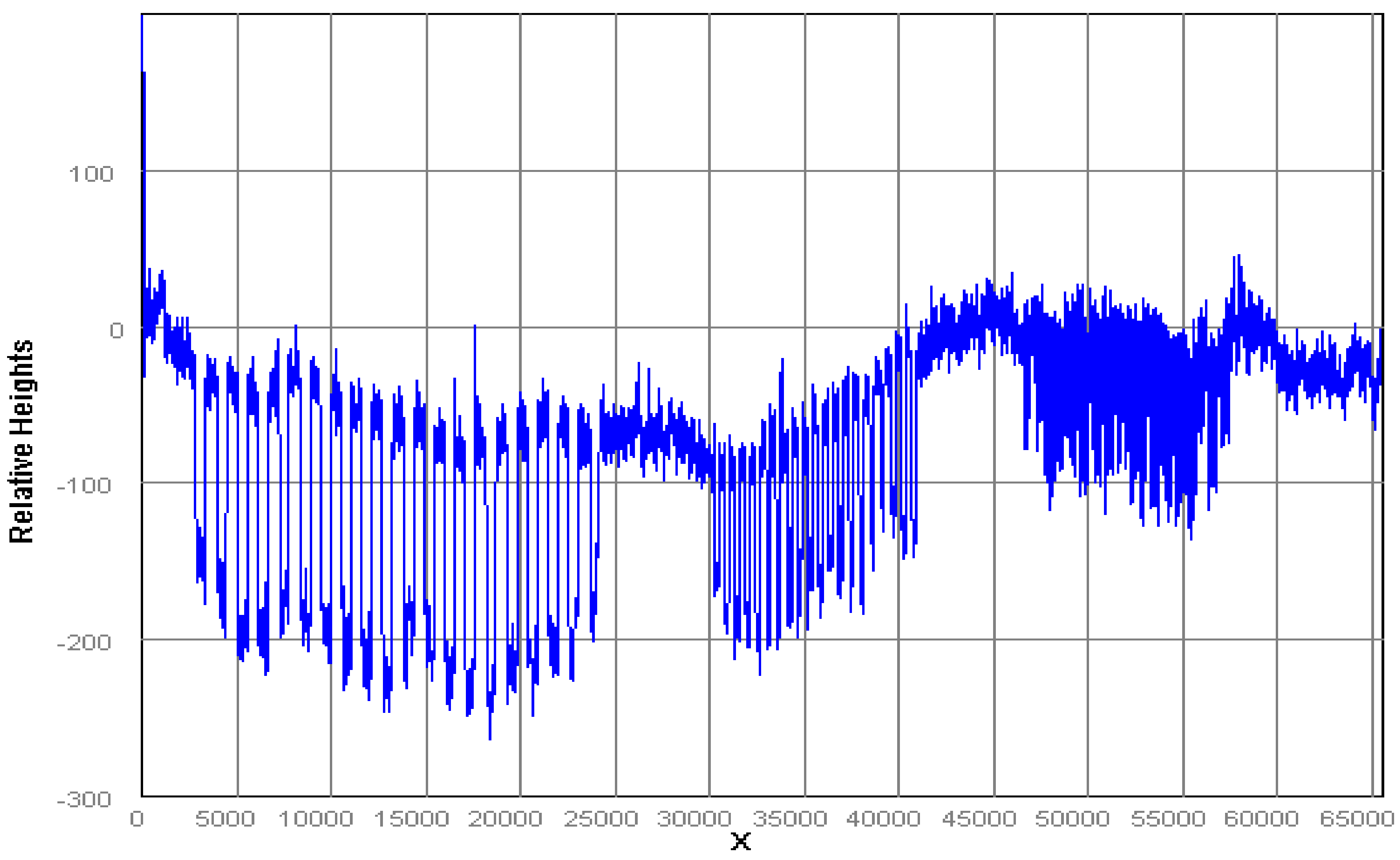


A1 Dish (Å)	A1 CE (Å)	A2 Dish (Å)	A2 CE (Å)	A3 Dish (Å)	A3 CE (Å)	A4 Dish (Å)	A4 CE (Å)	A5 Dish (Å)	A5 CE (Å)	A6 Dish (Å)	A6 CE (Å)	A7 Dish (Å)	A7 CE (Å)
211	35	170	19	136	18	73	9	48	9	26	8	13	6

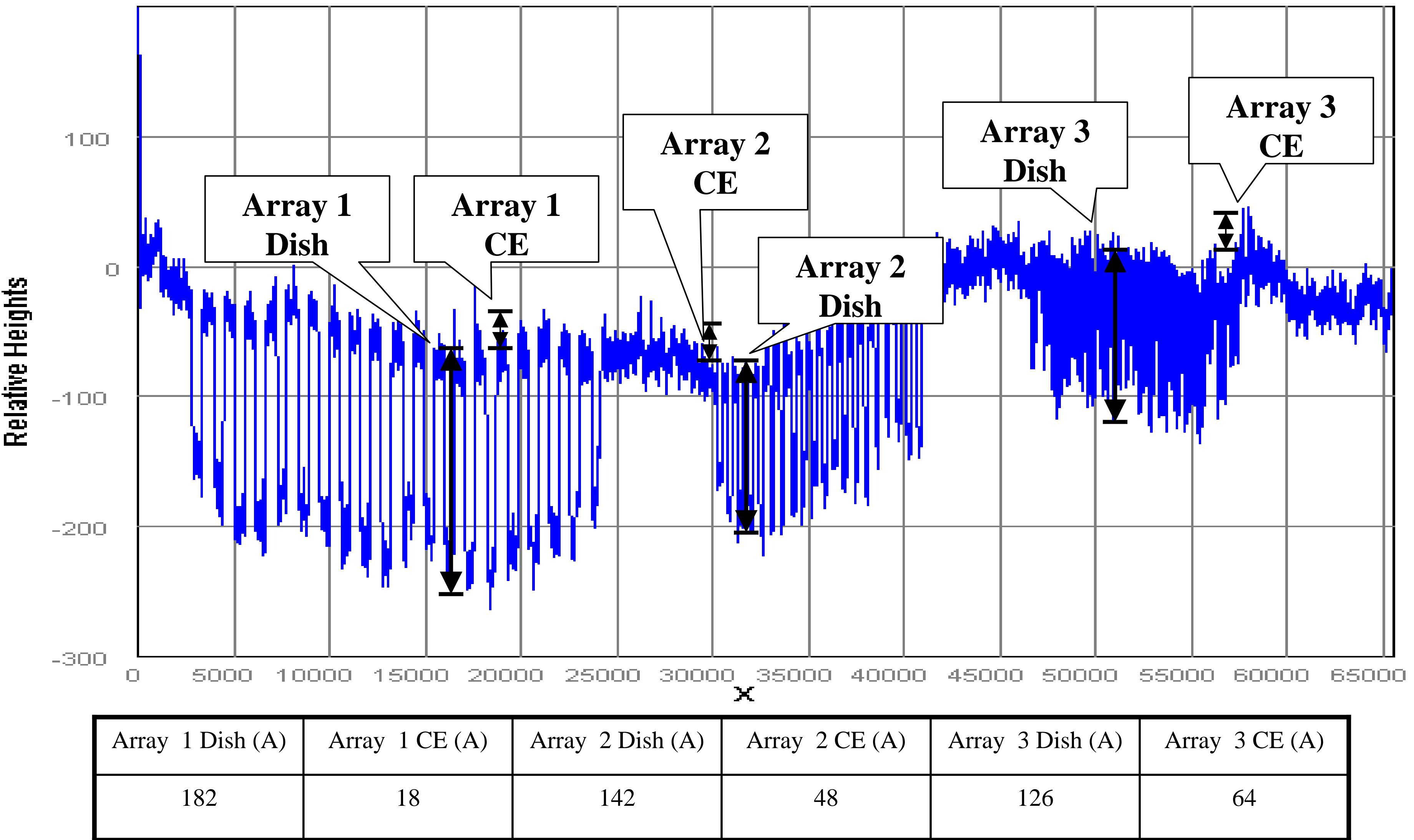
CMP_FANG2 Die Floor Plan



CMP_FANG2 Row 1 Line Profile

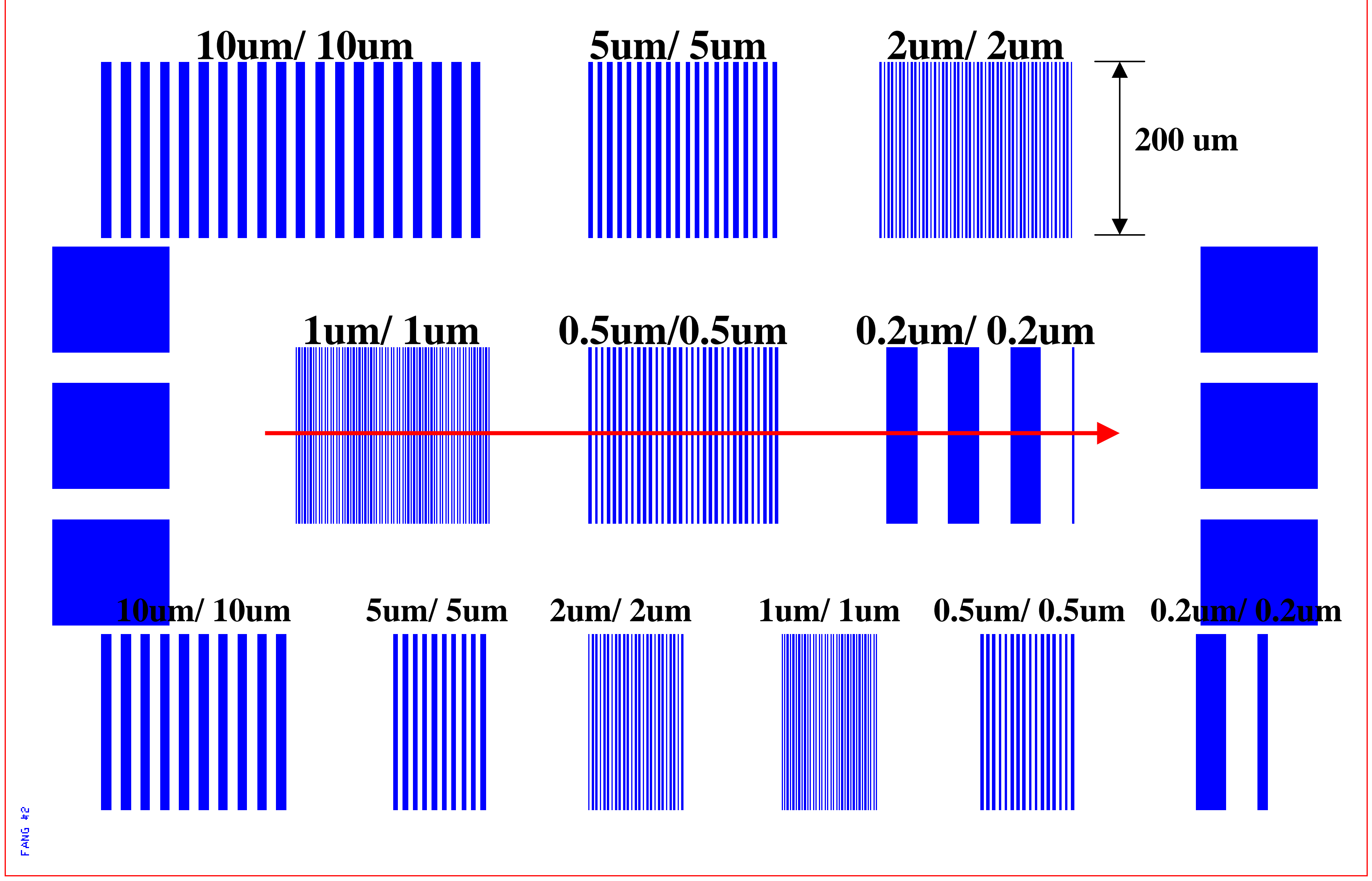


CMP_FANG2 Row 1 Line Profile

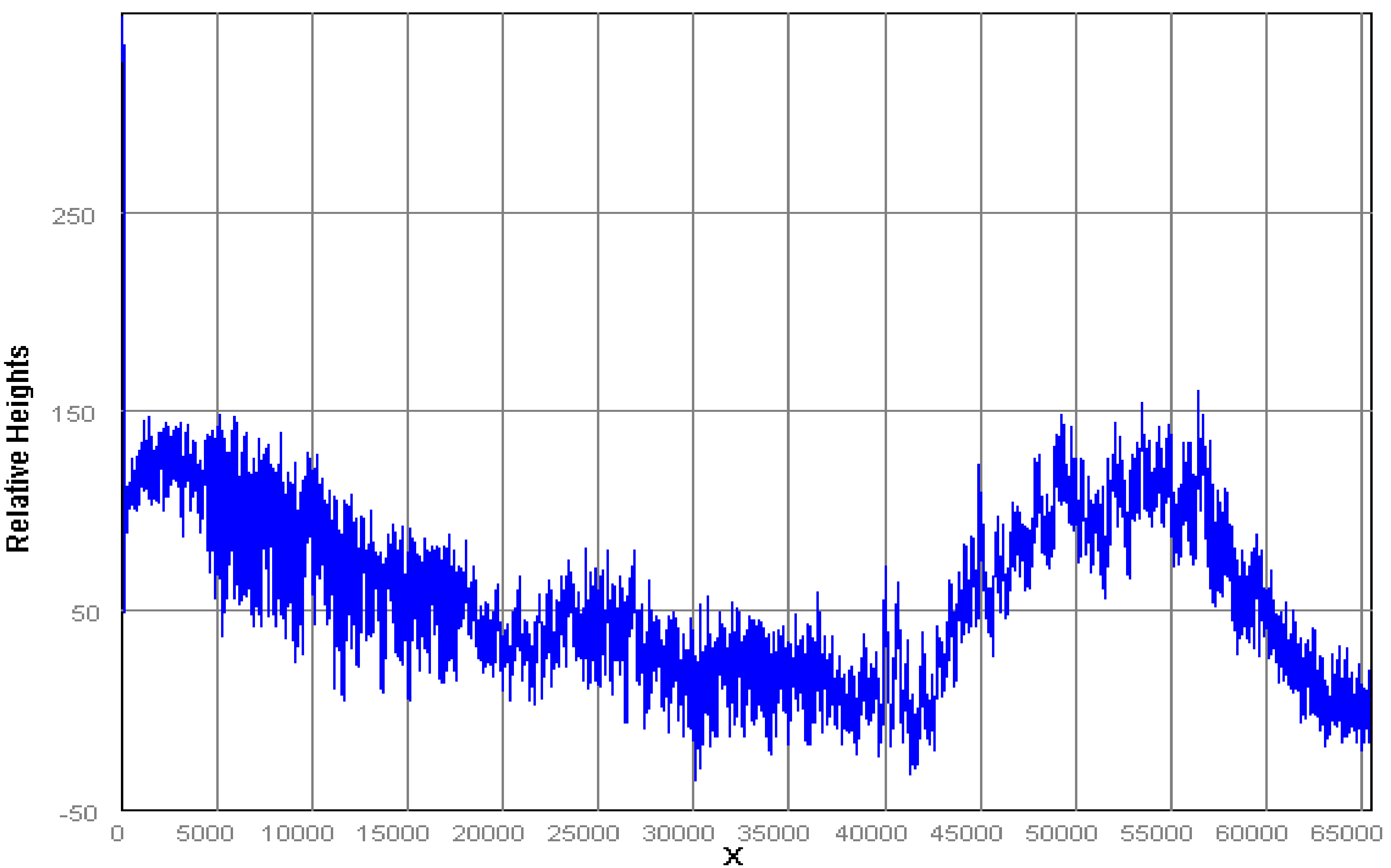


Array 1 Dish (A)	Array 1 CE (A)	Array 2 Dish (A)	Array 2 CE (A)	Array 3 Dish (A)	Array 3 CE (A)
182	18	142	48	126	64

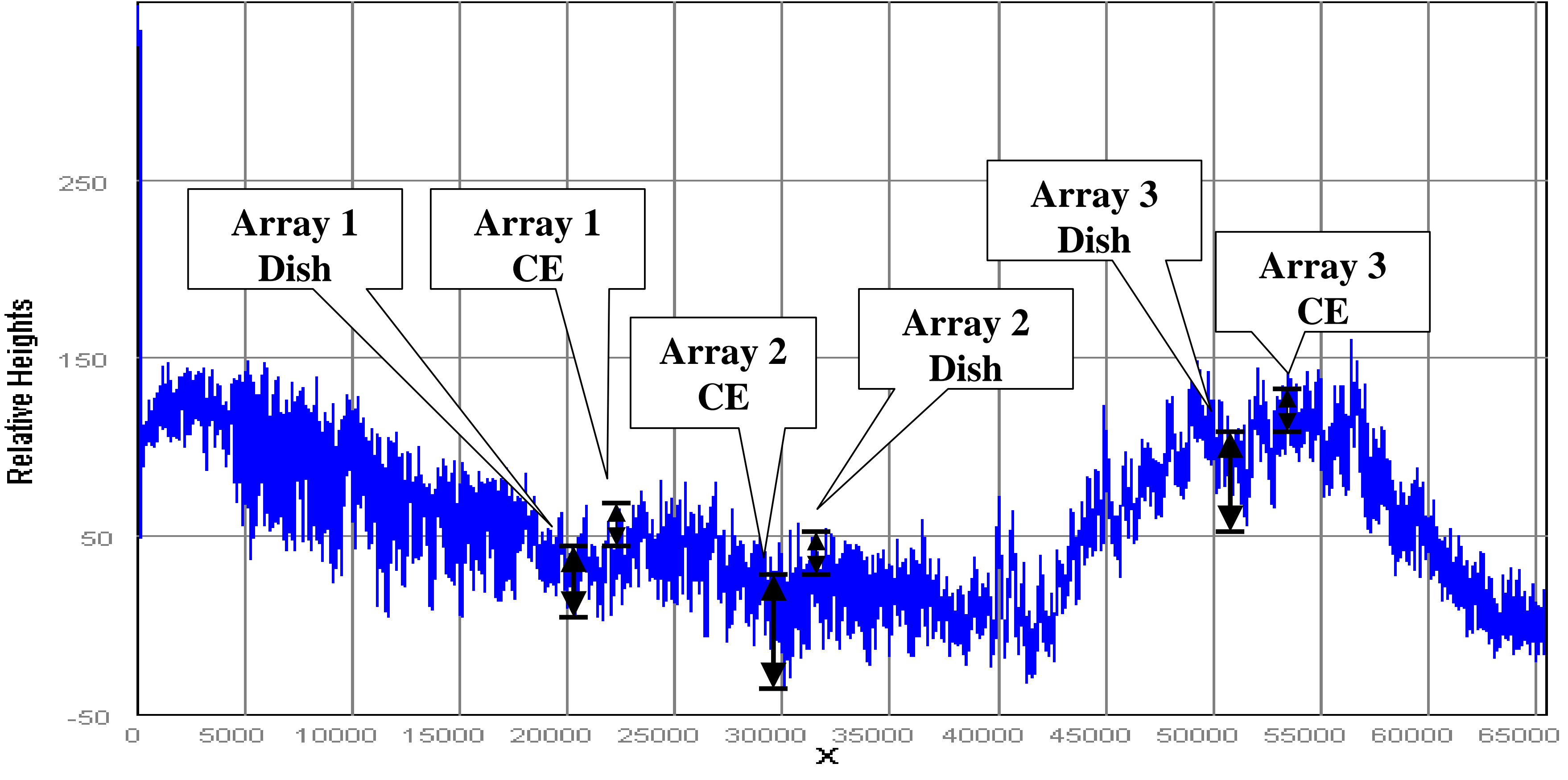
CMP_FANG2 Die Floor Plan



CMP_FANG2 Row 2 Line Profile

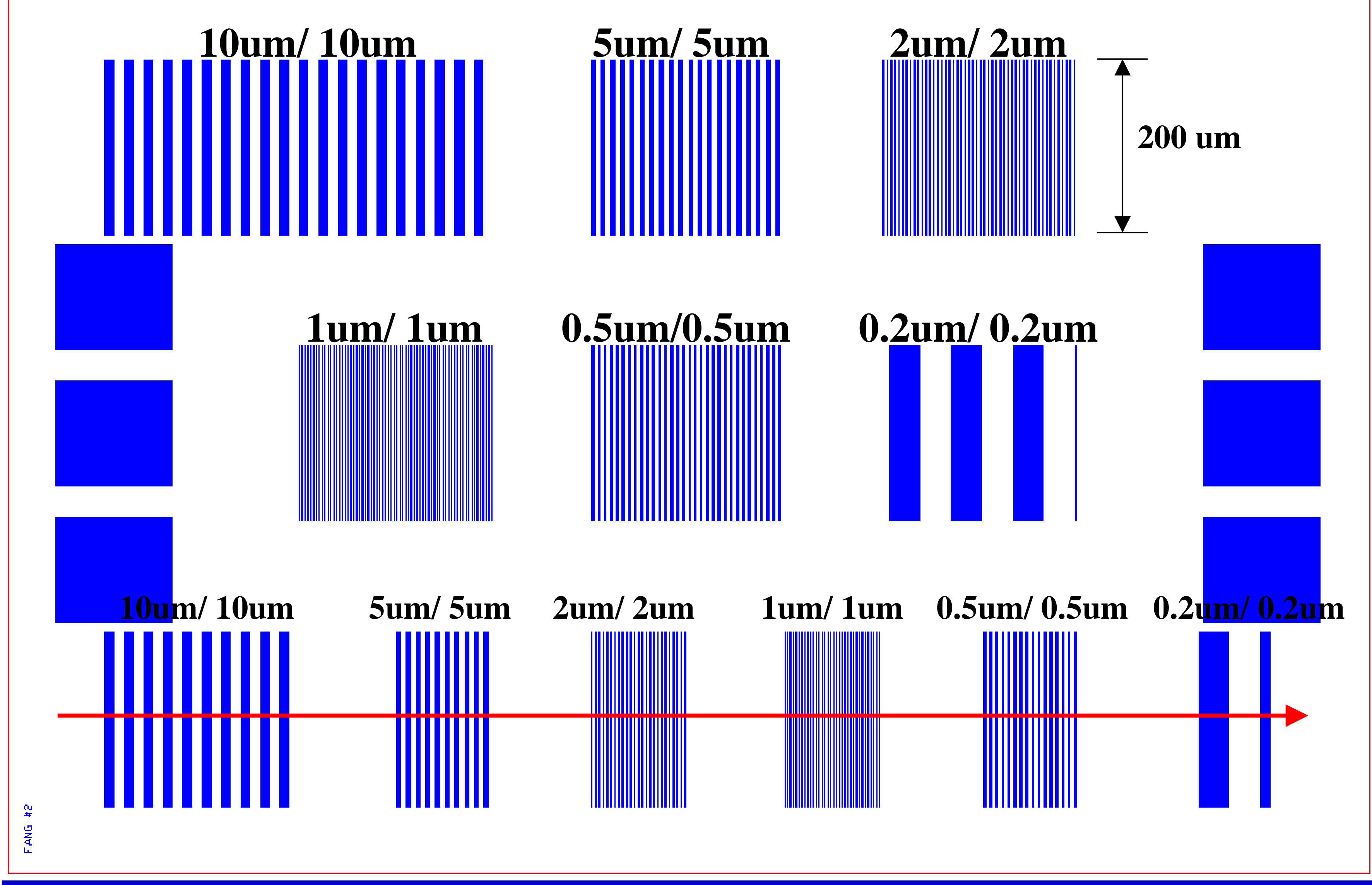


CMP_FANG2 Row 2 Line Profile

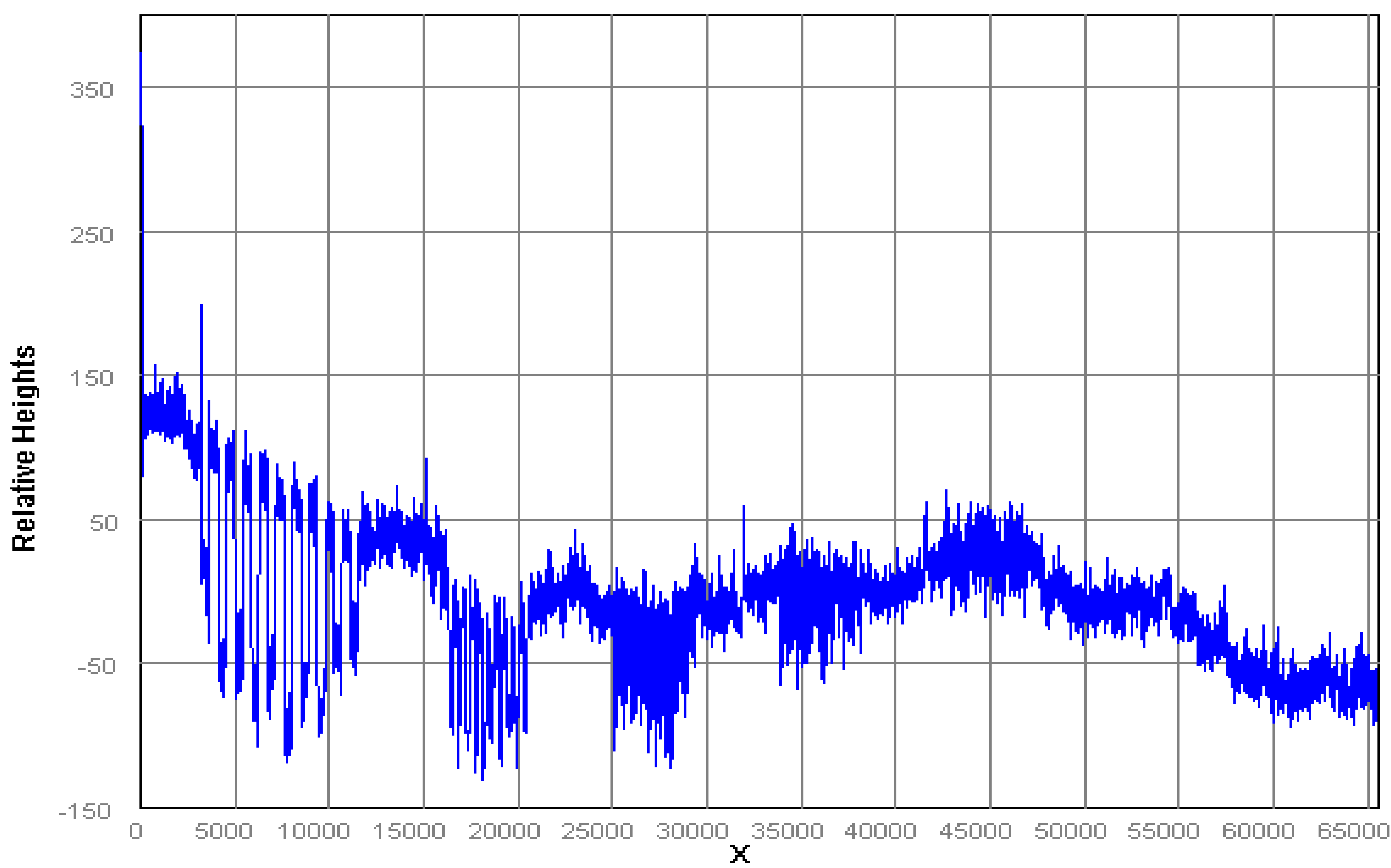


Array 1 Dish (A)	Array 1 CE (A)	Array 2 Dish (A)	Array 2 CE (A)	Array 3 Dish (A)	Array 3 CE (A)
87	78	55	86	36	95

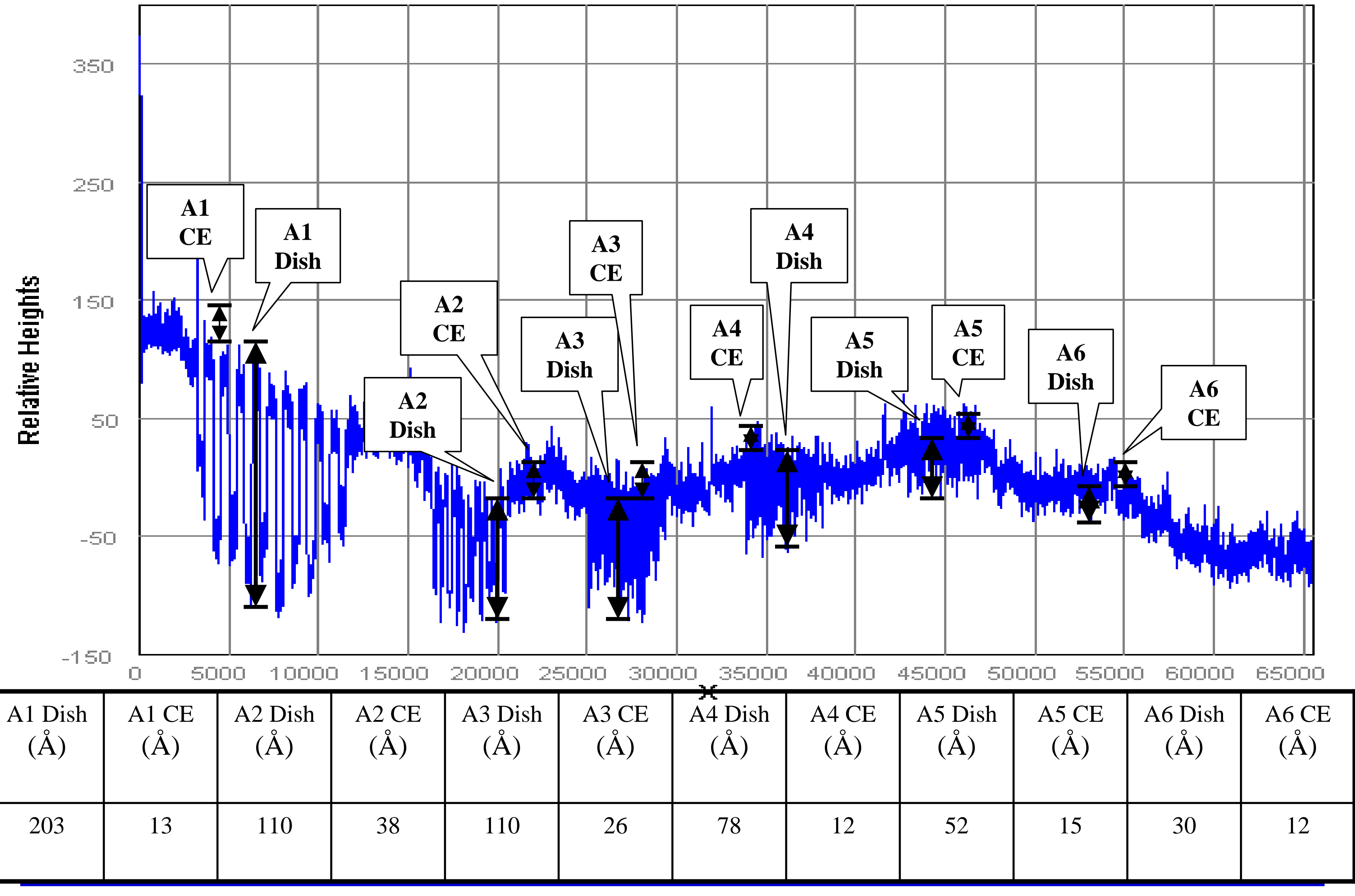
CMP_FANG2 Die Floor Plan



CMP_FANG2 Row 3 Line Profile

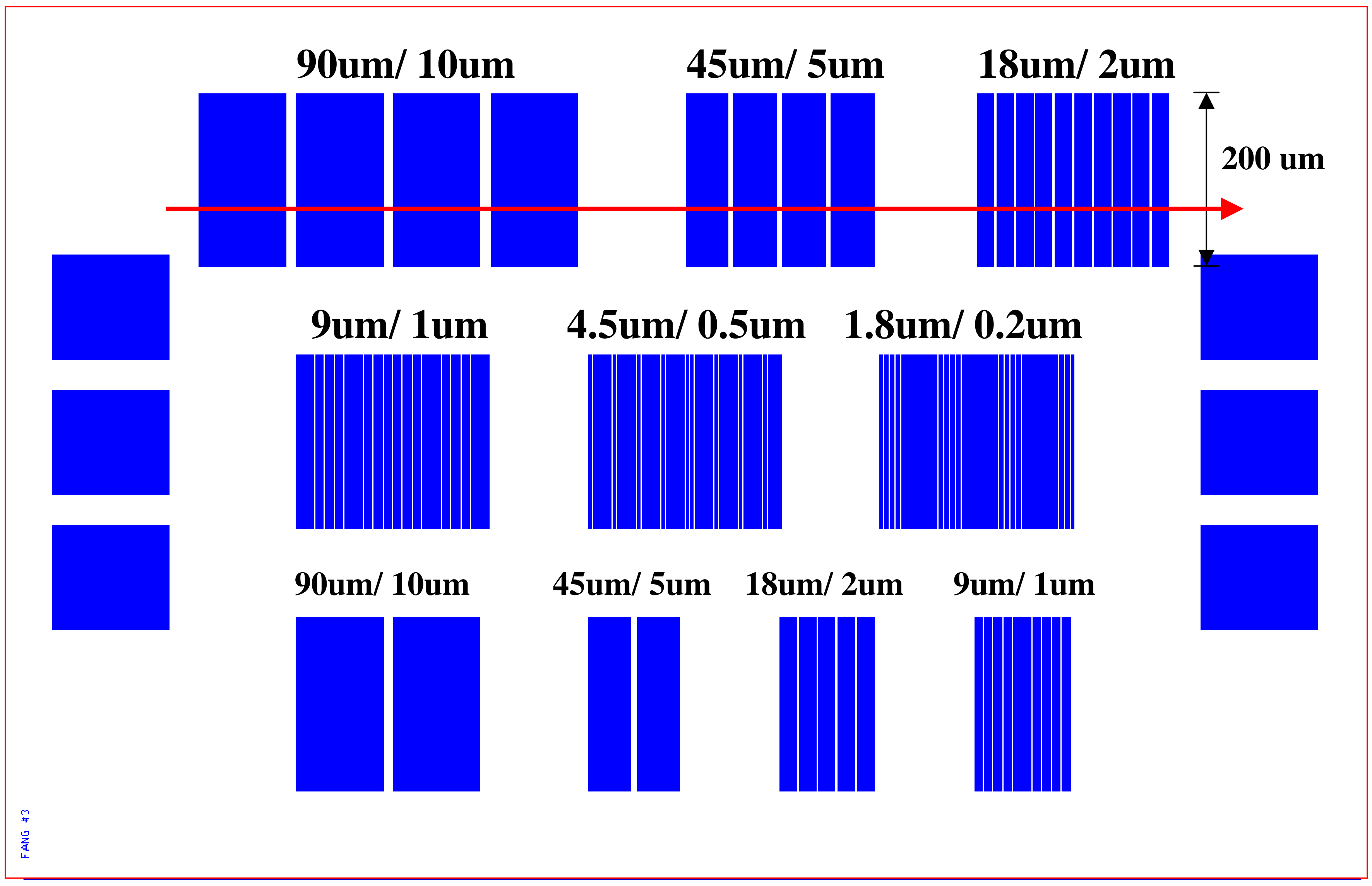


CMP_FANG2 Row 3 Line Profile

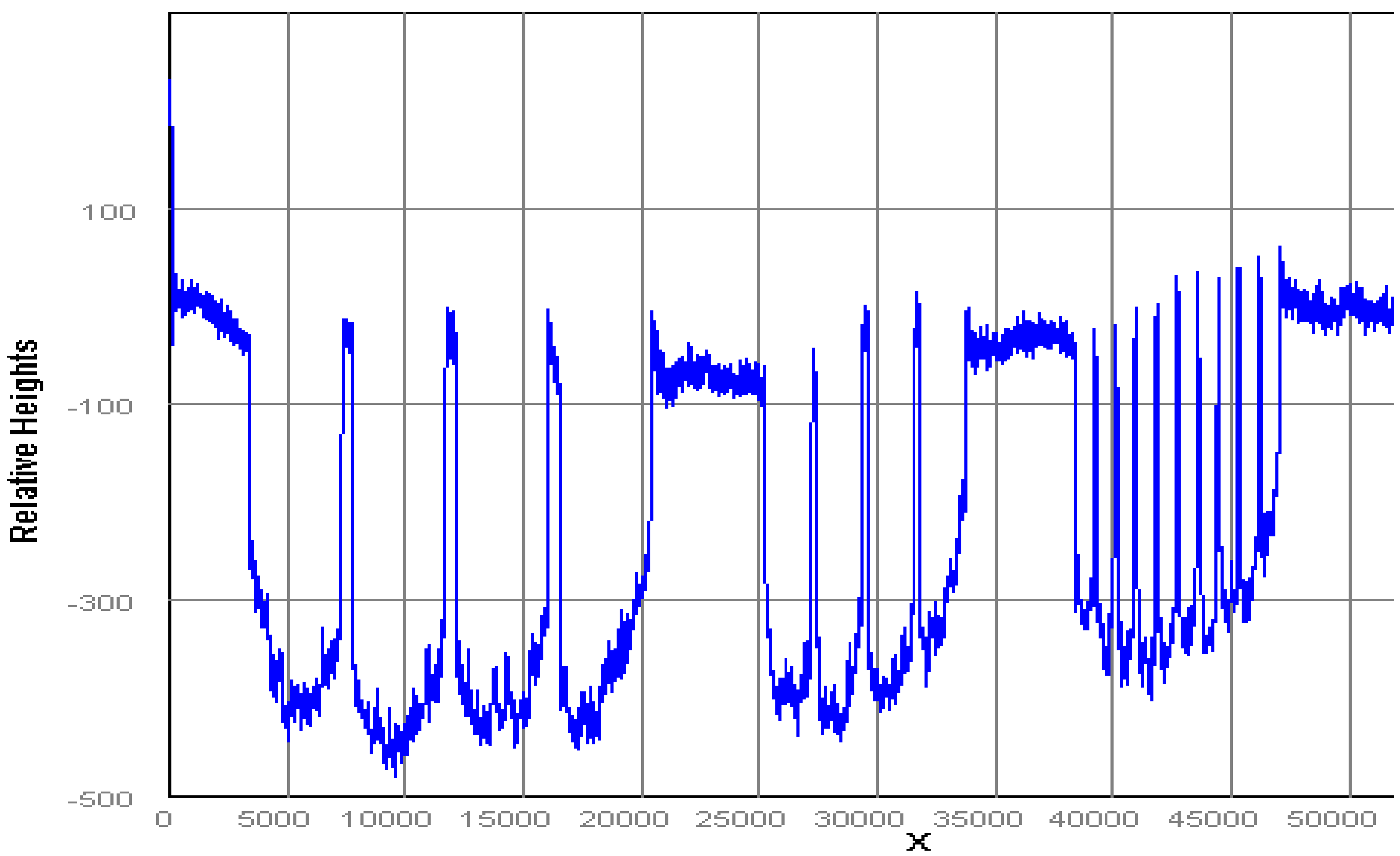


A1 Dish (Å)	A1 CE (Å)	A2 Dish (Å)	A2 CE (Å)	A3 Dish (Å)	A3 CE (Å)	A4 Dish (Å)	A4 CE (Å)	A5 Dish (Å)	A5 CE (Å)	A6 Dish (Å)	A6 CE (Å)
203	13	110	38	110	26	78	12	52	15	30	12

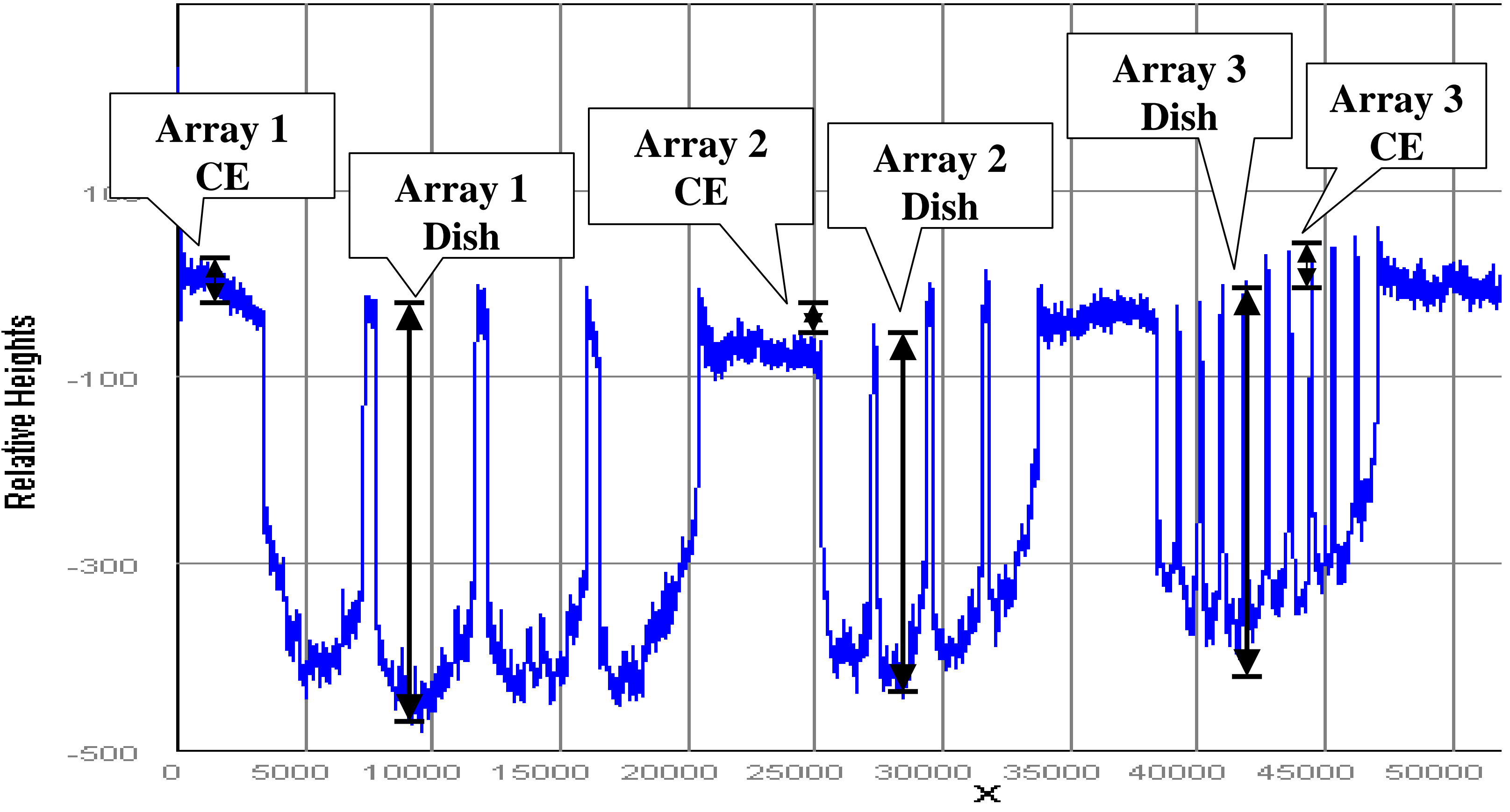
CMP_FANG3 Die Floor Plan



CMP_FANG3 Row 1 Line Profile

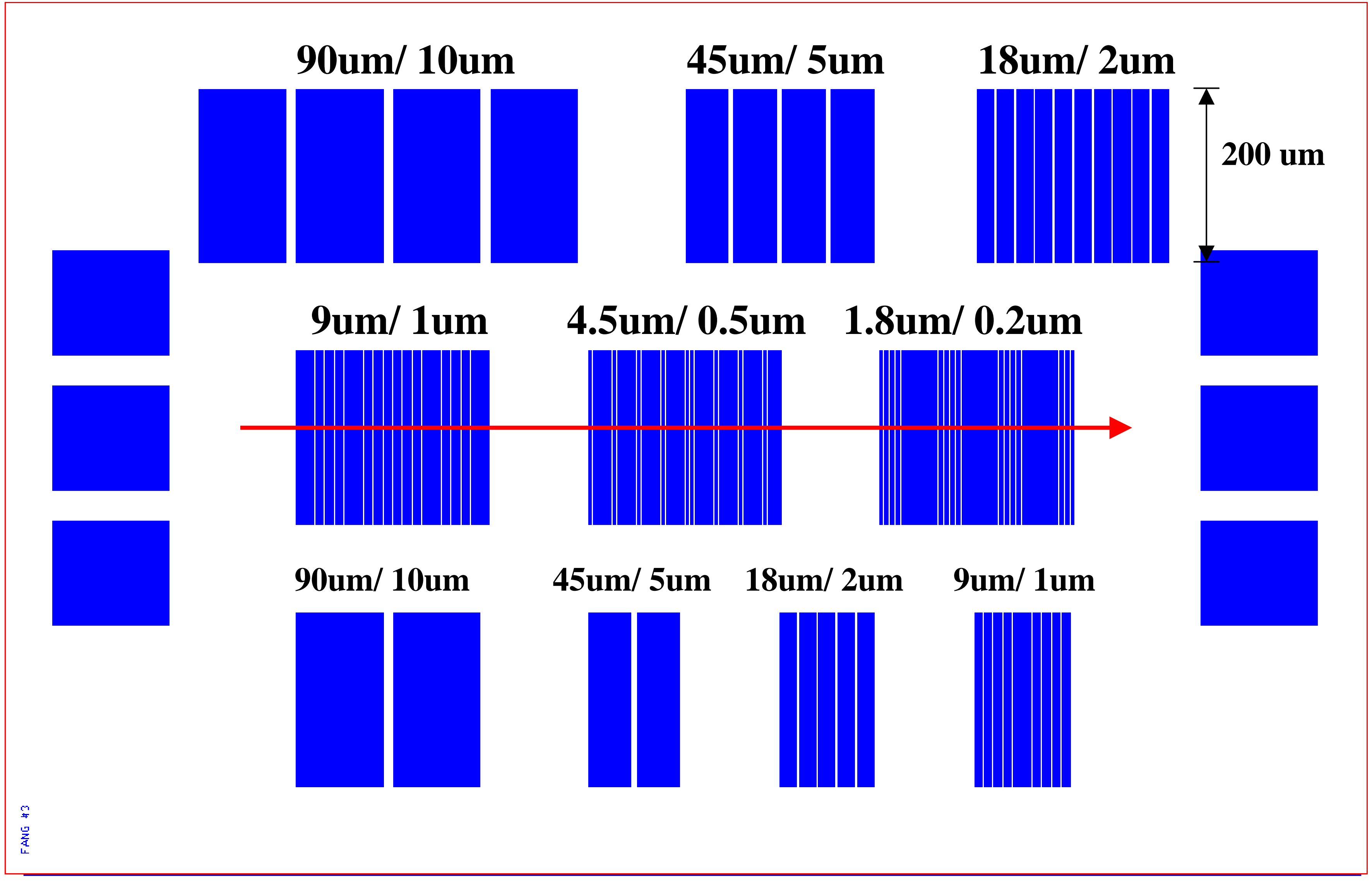


CMP_FANG3 Row 1 Line Profile

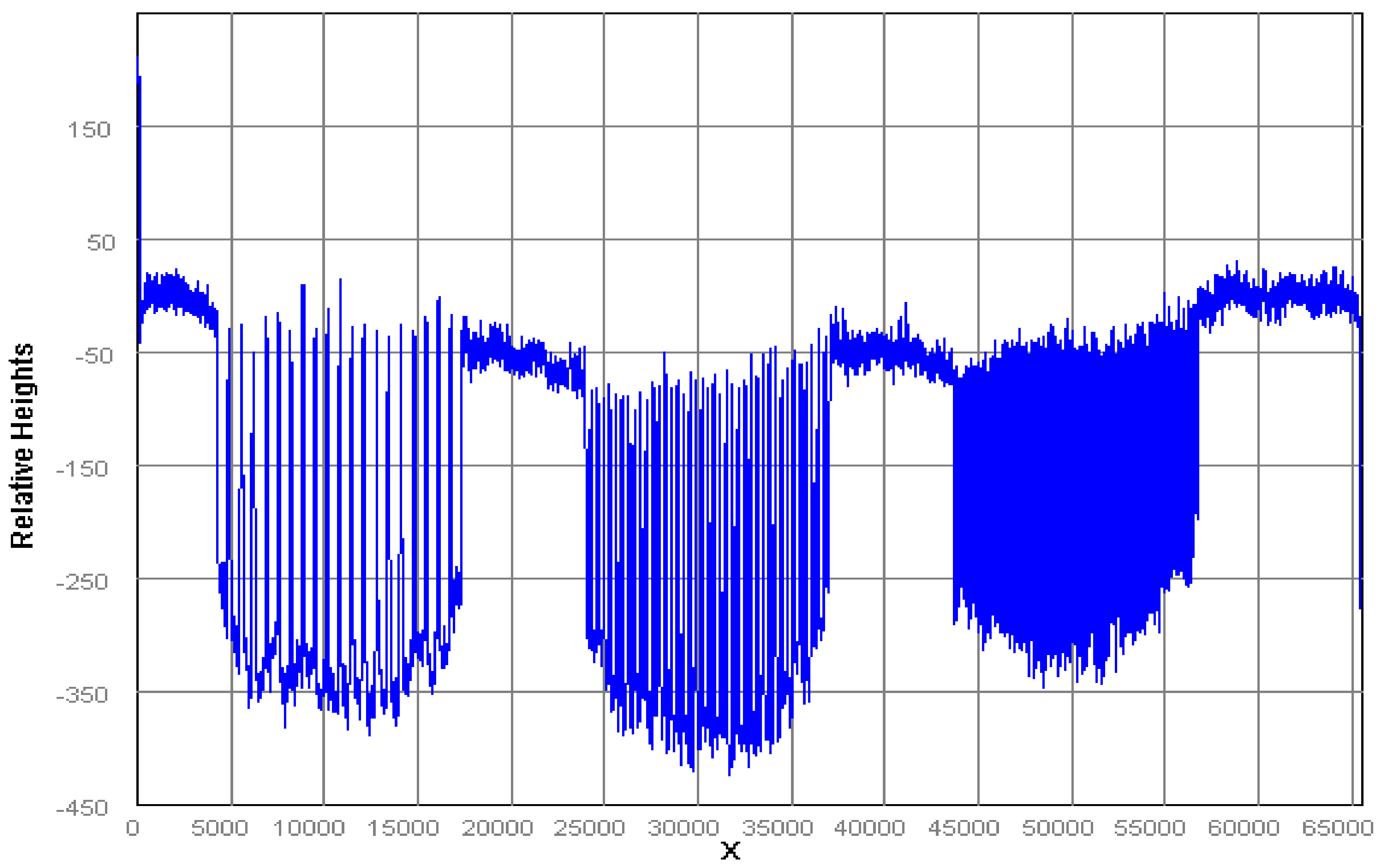


Array 1 Dish (A)	Array 1 CE (A)	Array 2 Dish (A)	Array 2 CE (A)	Array 3 Dish (A)	Array 3 CE (A)
419	35	397	12	397	18

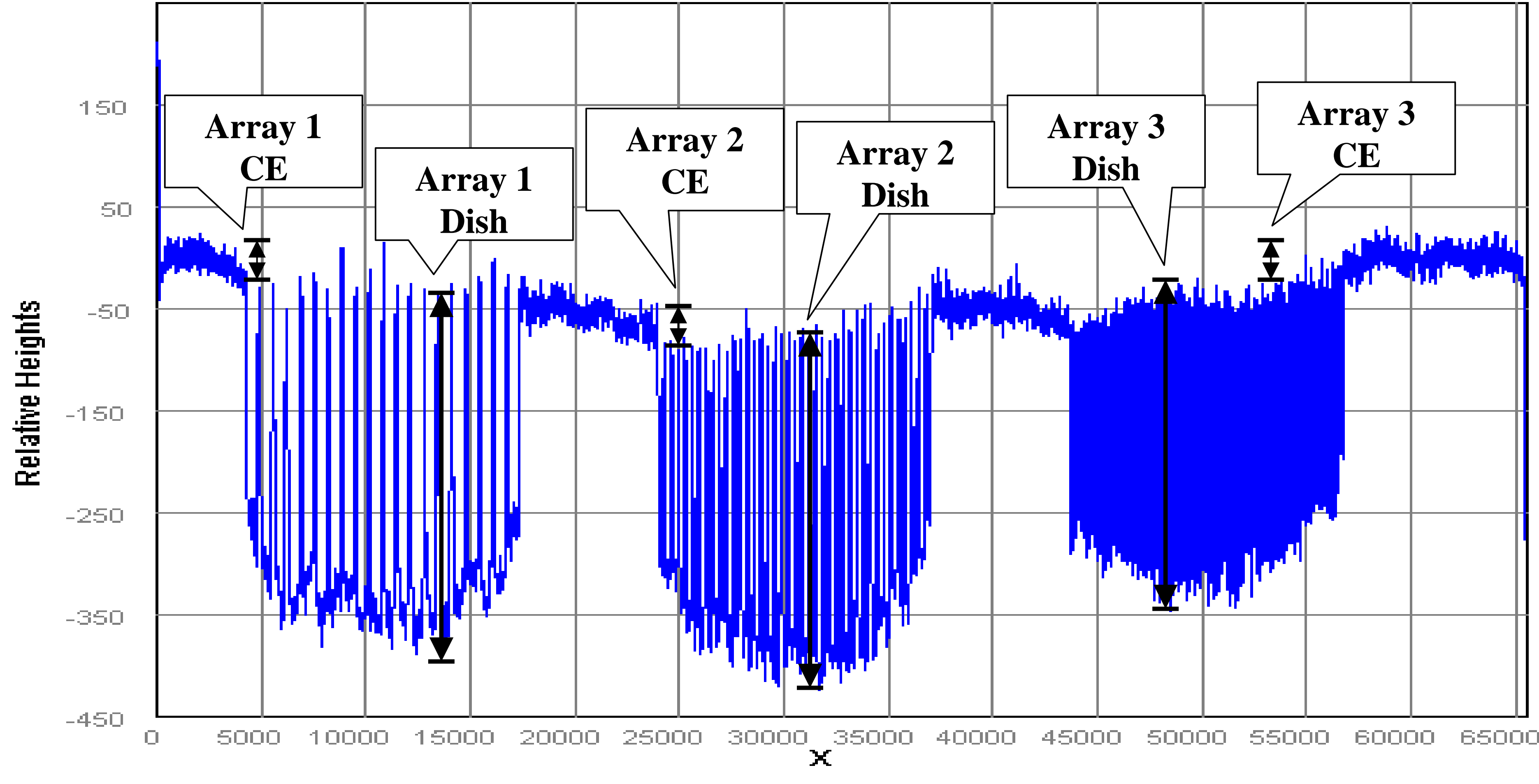
CMP_FANG3 Die Floor Plan



CMP_FANG3 Row 2 Line Profile

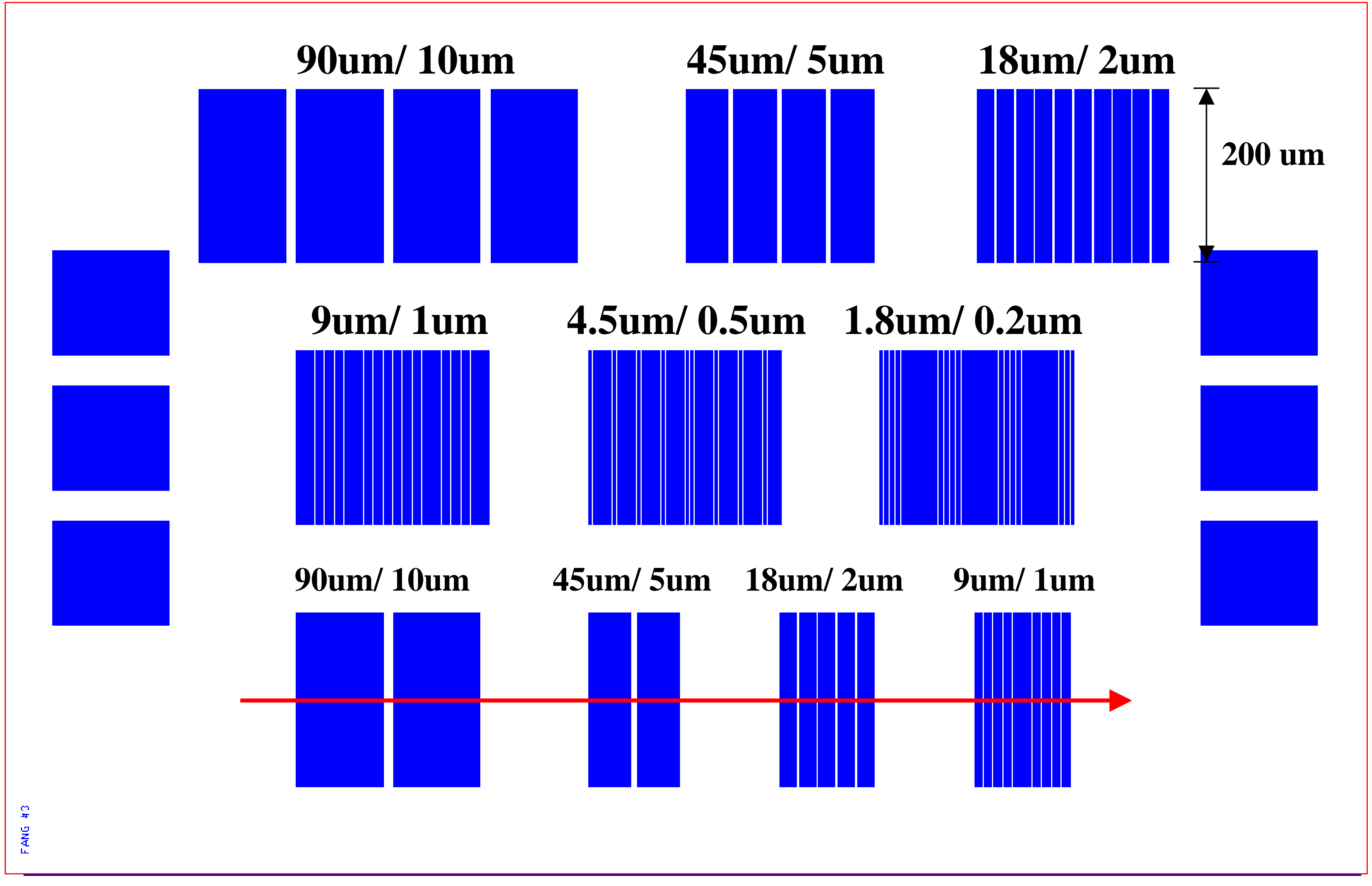


CMP_FANG3 Row 2 Line Profile

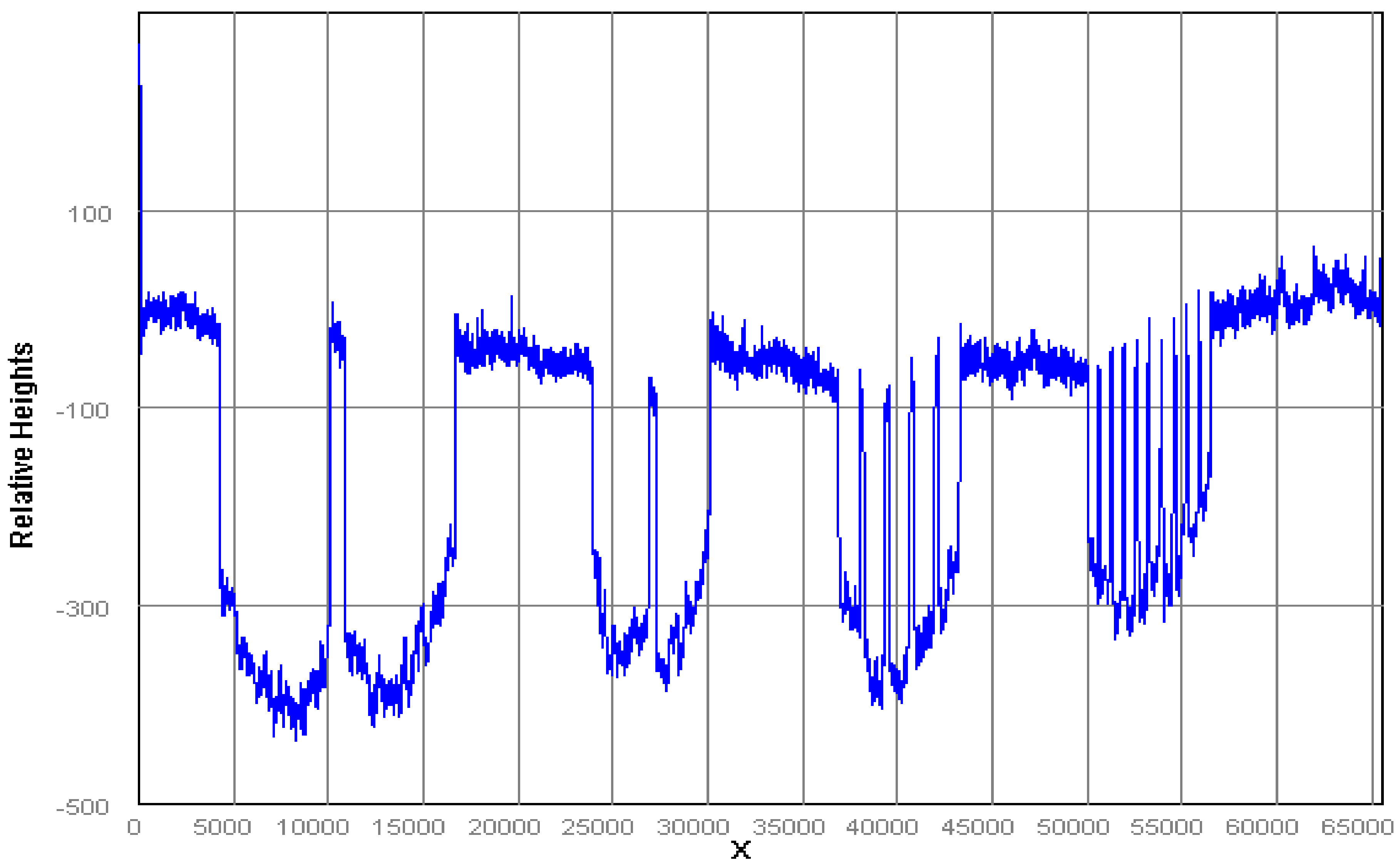


Array 1 Dish (A)	Array 1 CE (A)	Array 2 Dish (A)	Array 2 CE (A)	Array 3 Dish (A)	Array 3 CE (A)
348	25	342	33	311	46

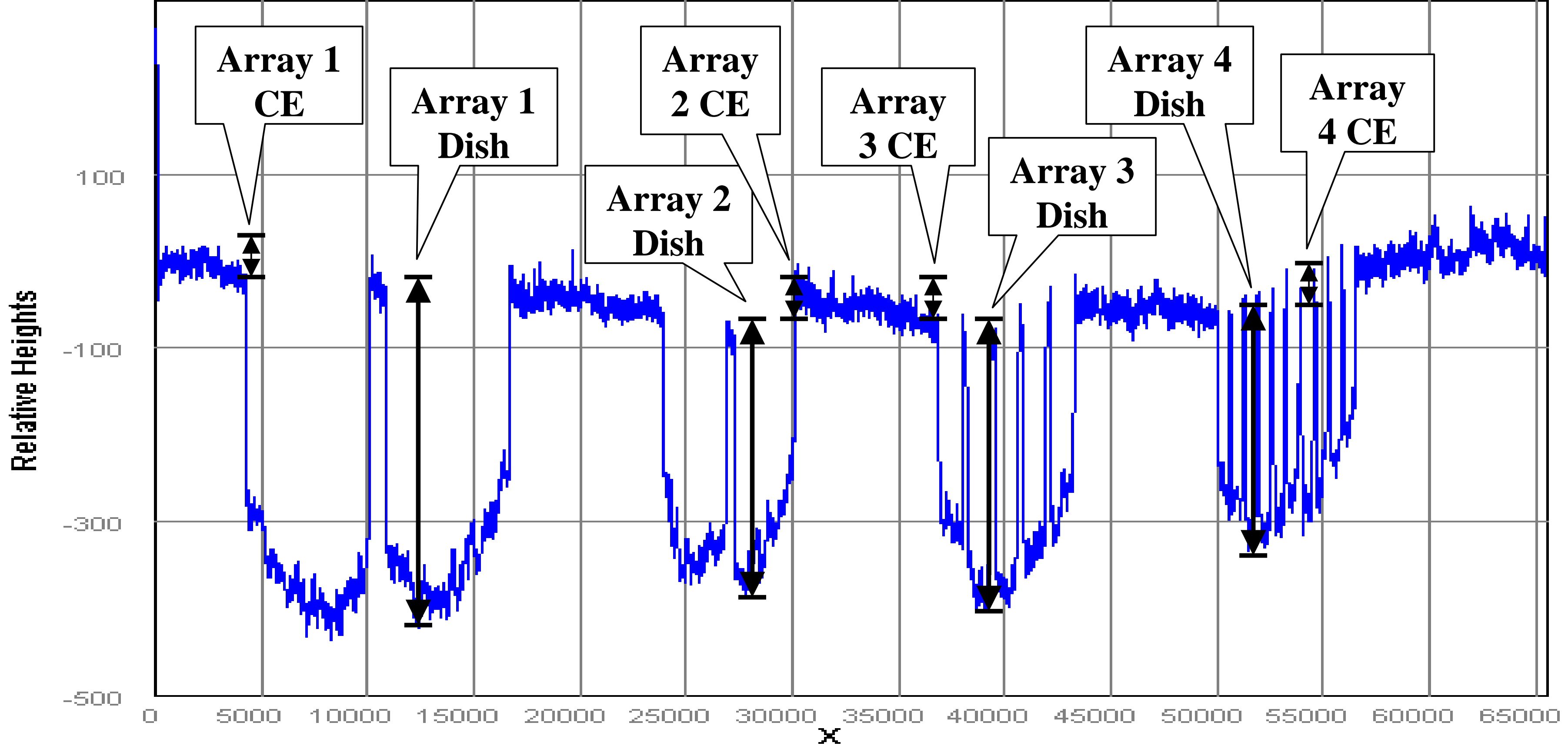
CMP_FANG3 Die Floor Plan



CMP_FANG3 Row 3 Line Profile

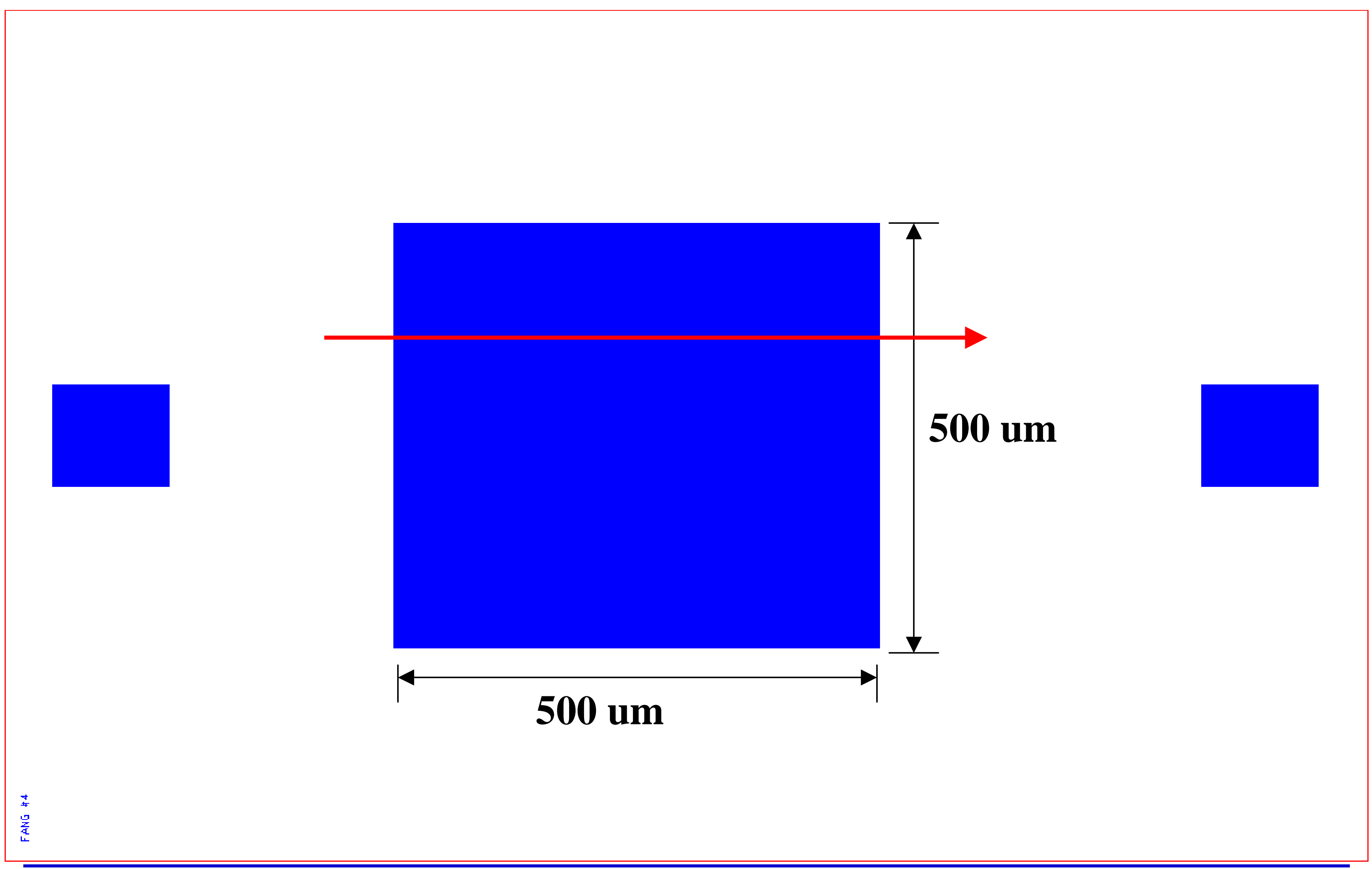


CMP_FANG3 Row 3 Line Profile

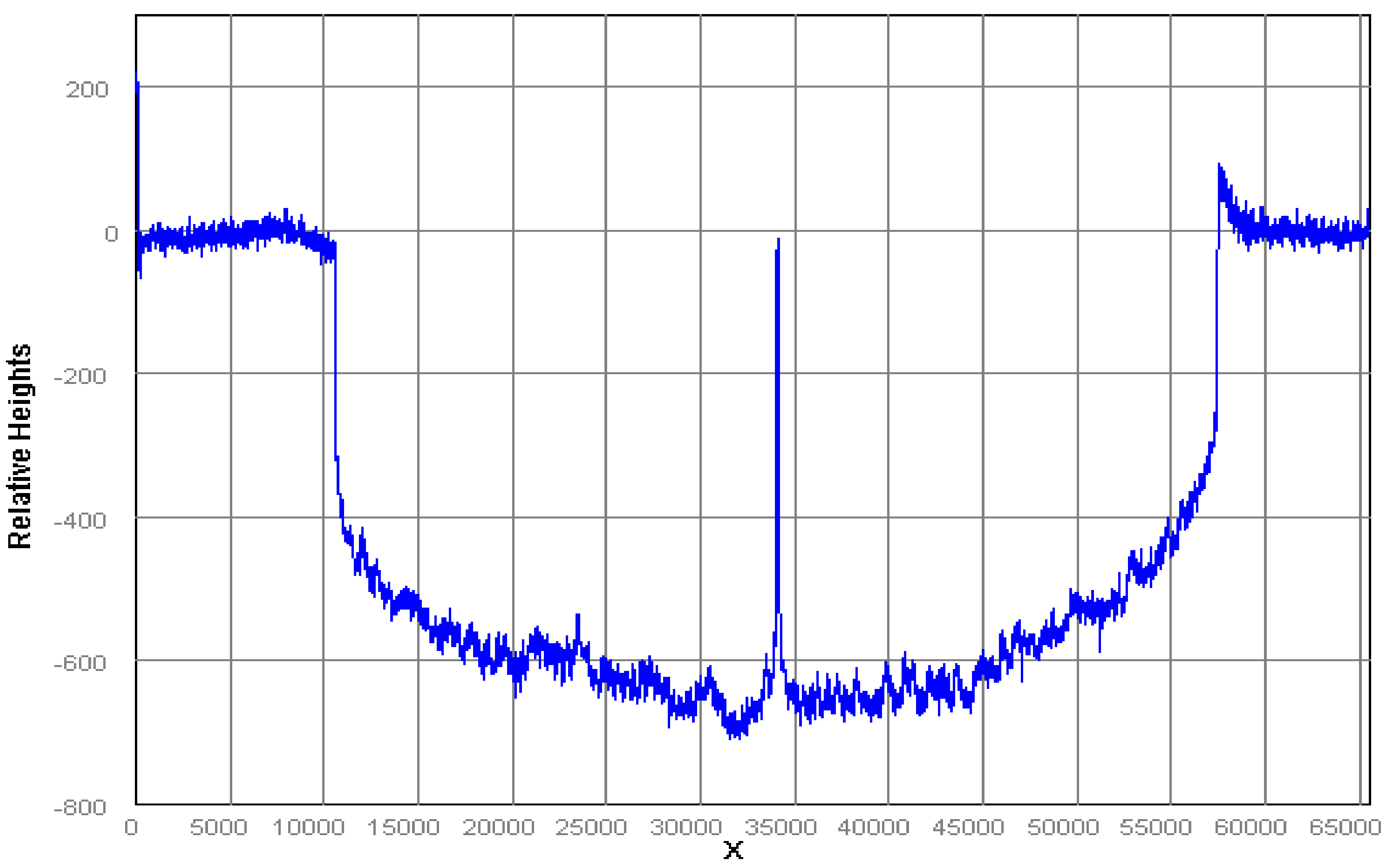


Array 1 Dish (A)	Array 1 CE (A)	Array 2 Dish (A)	Array 2 CE (A)	Array 3 Dish (A)	Array 3 CE (A)	Array 4 Dish (A)	Array 4 CE (A)
415	30	313	34	303	48	280	56

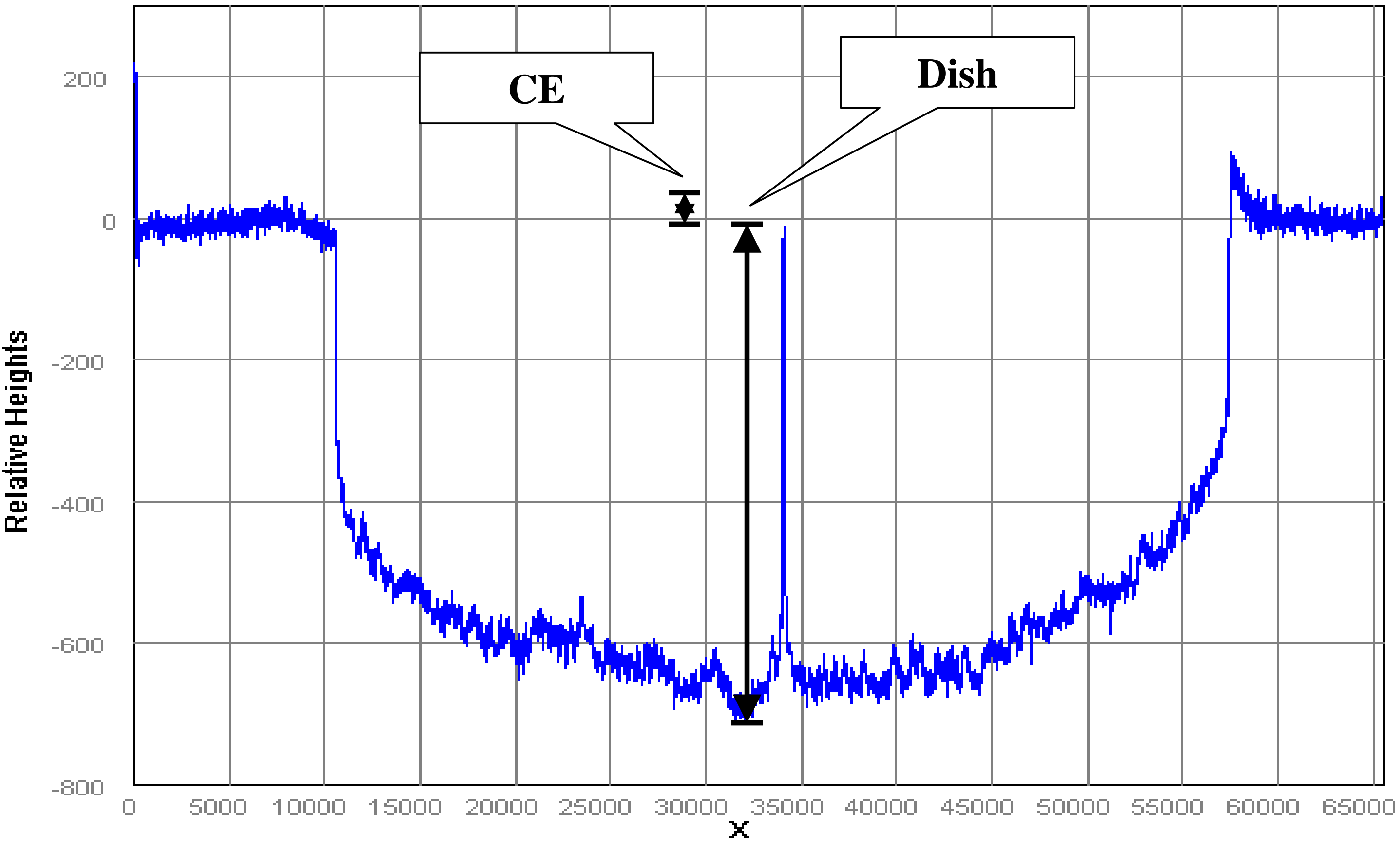
CMP_FANG4 Die Floor Plan



CMP_FANG4 Row 1 Line Profile

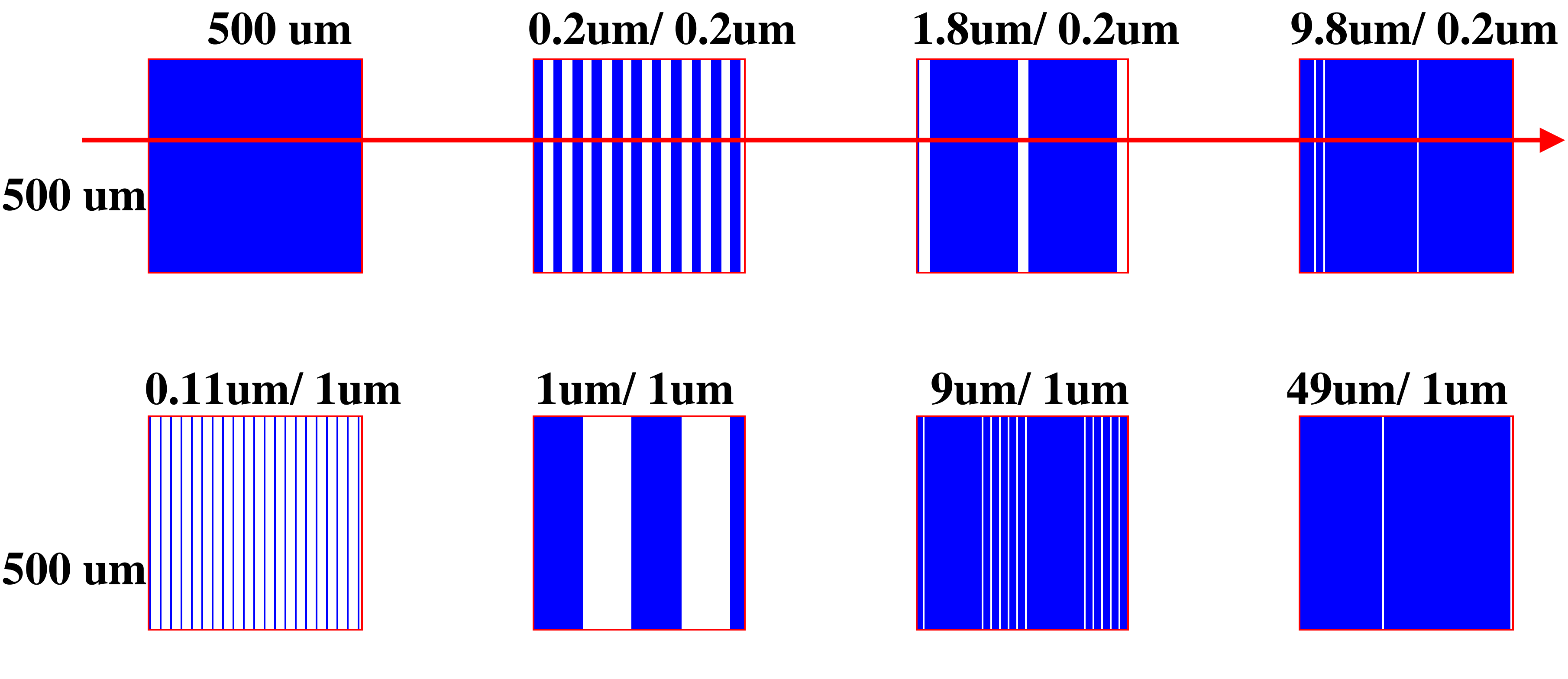


CMP_FANG4 Row 1 Line Profile

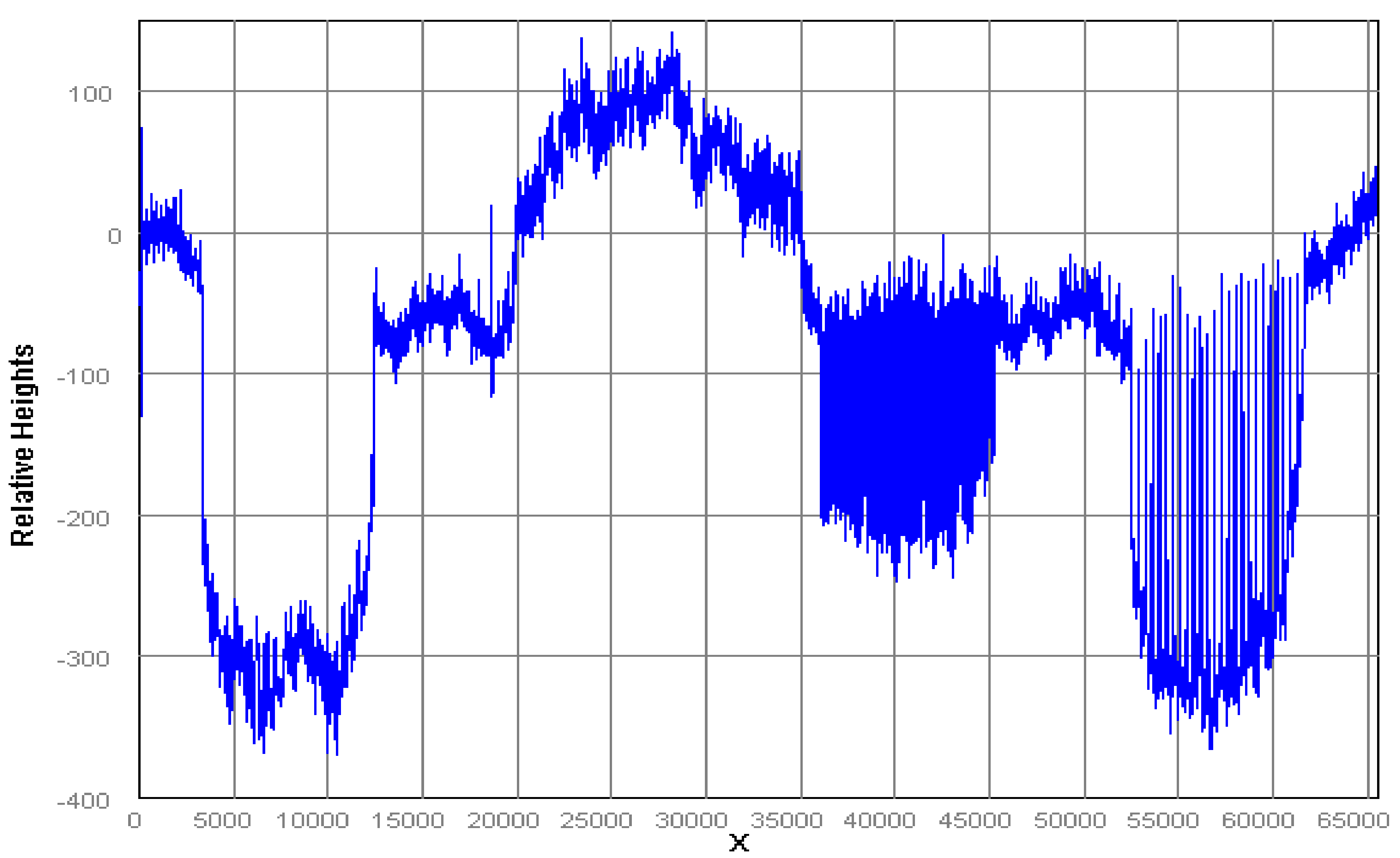


Dish (A)	CE (A)
692	30

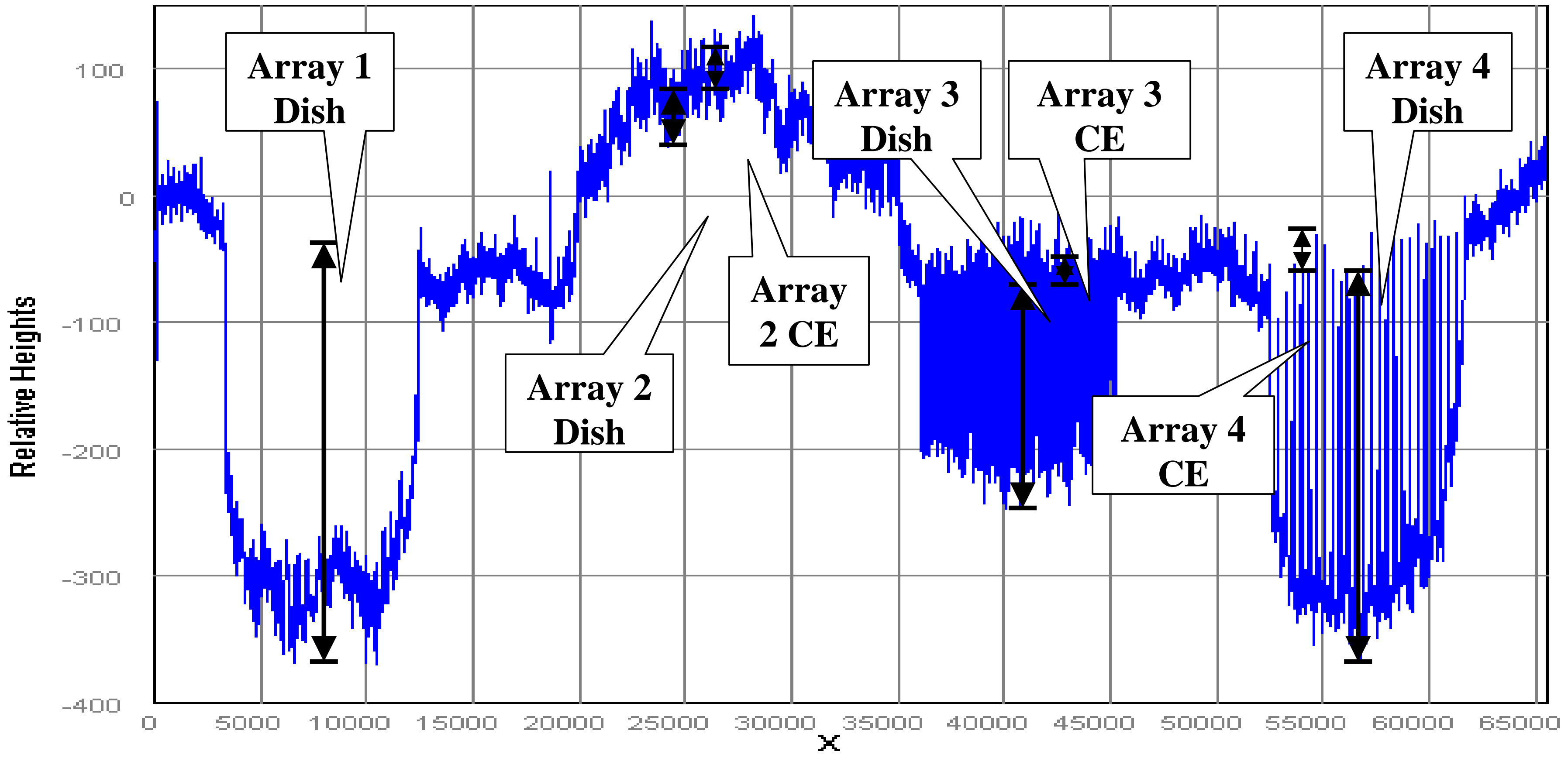
CMP Pads at Metal 1



CMP Pads Row 1 Line Profile

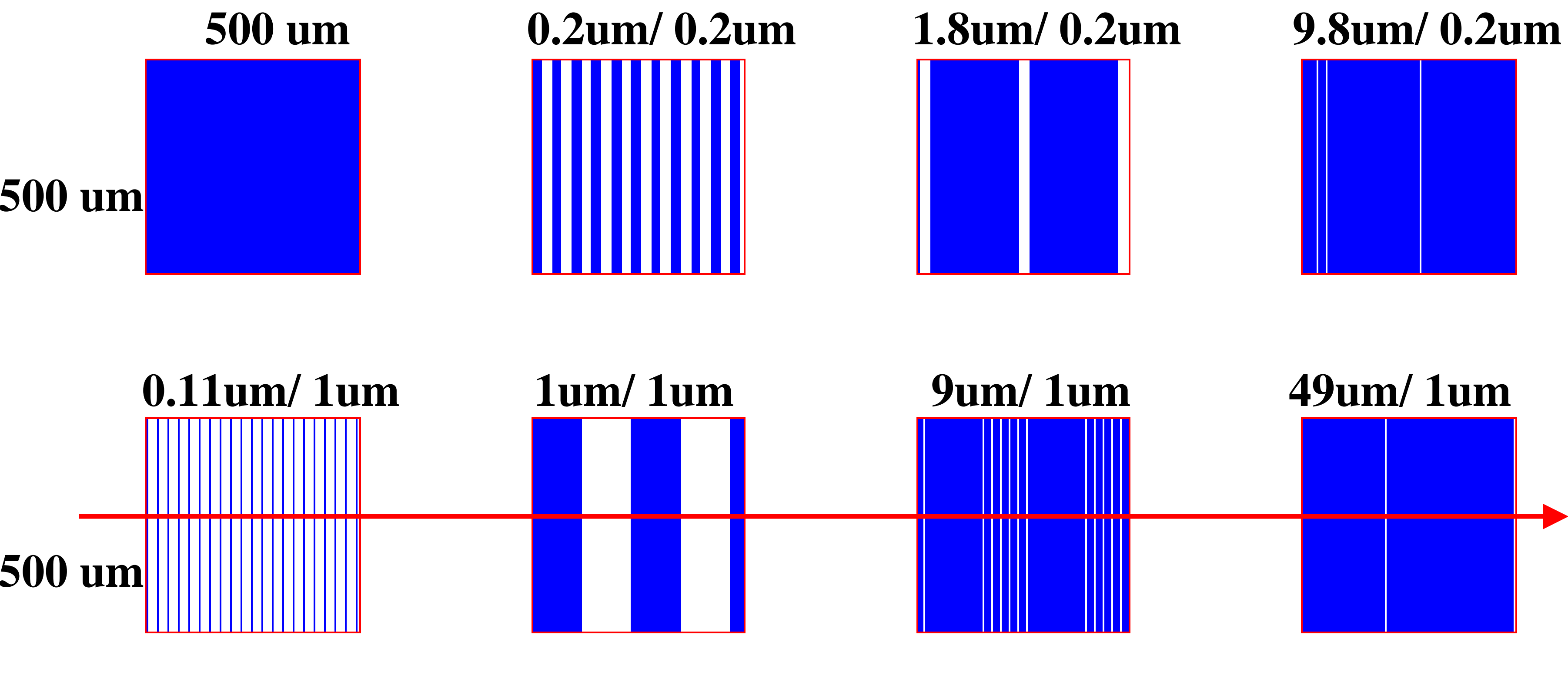


CMP Pads Row 1 Line Profile

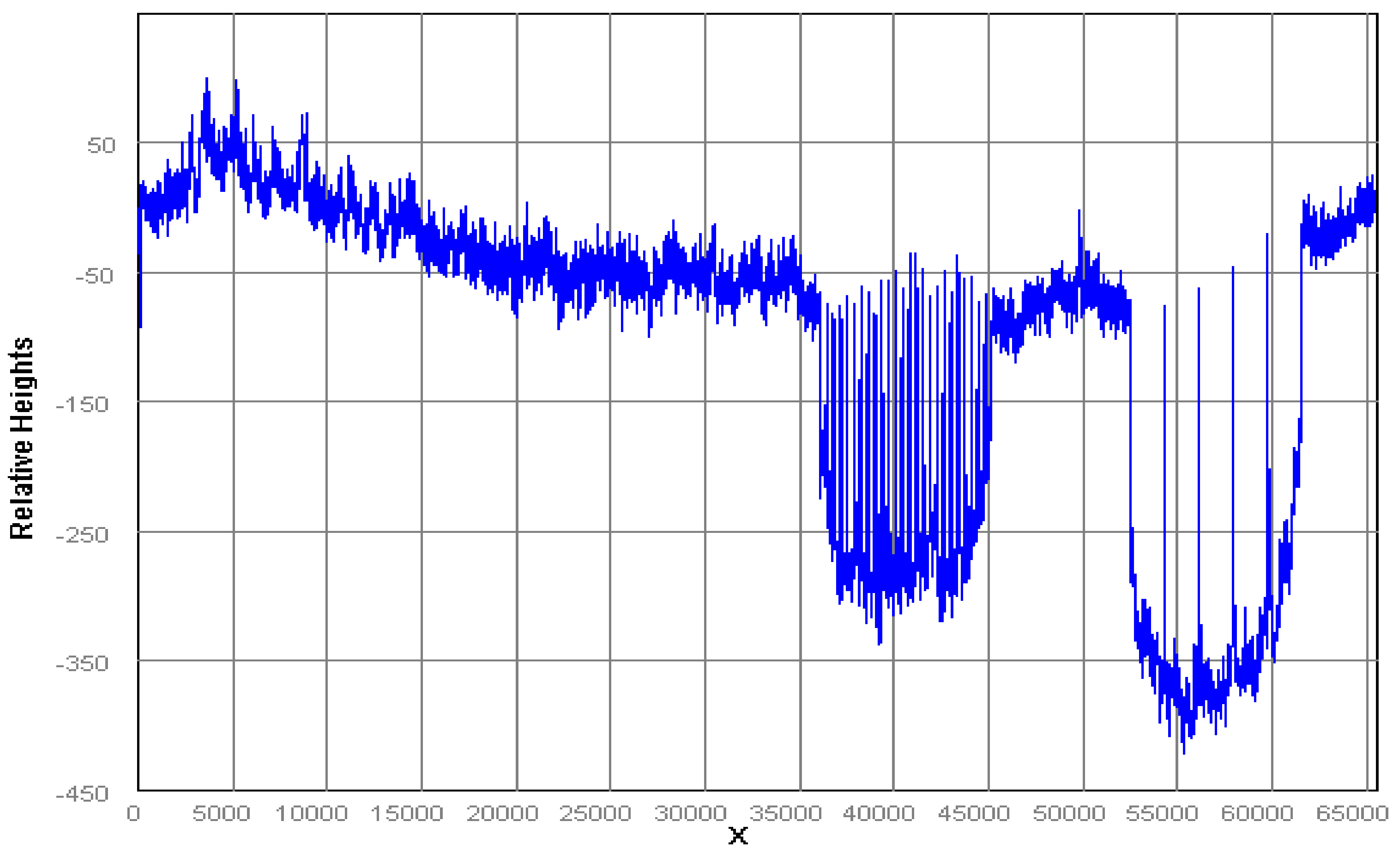


Array 1 Dish (A)	Array 2 Dish (A)	Array 2 CE (A)	Array 3 Dish (A)	Array 3 CE (A)	Array 4 Dish (A)	Array 4 CE (A)
335	36	95	180	21	292	34

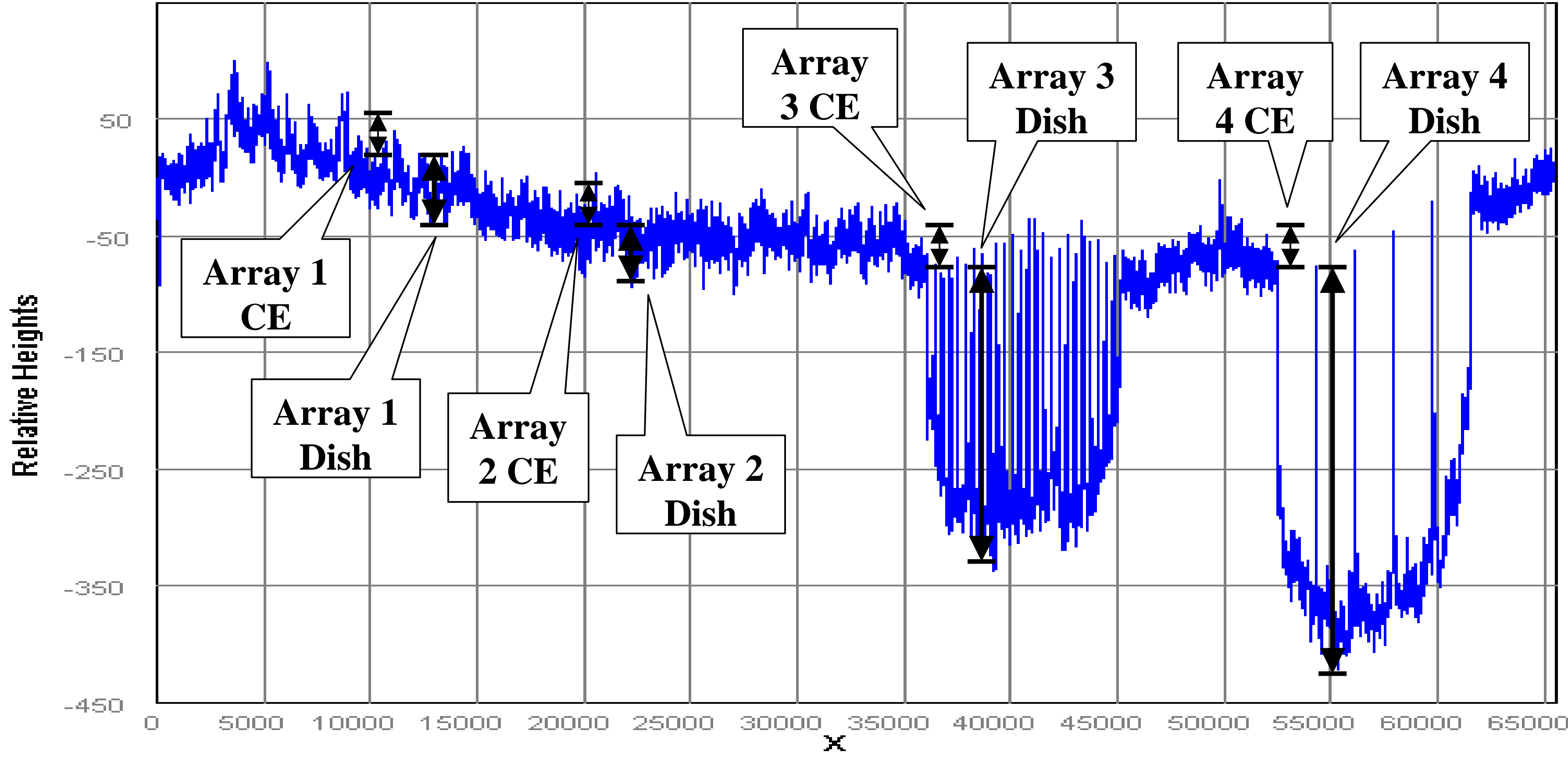
CMP Pads at Metal 1



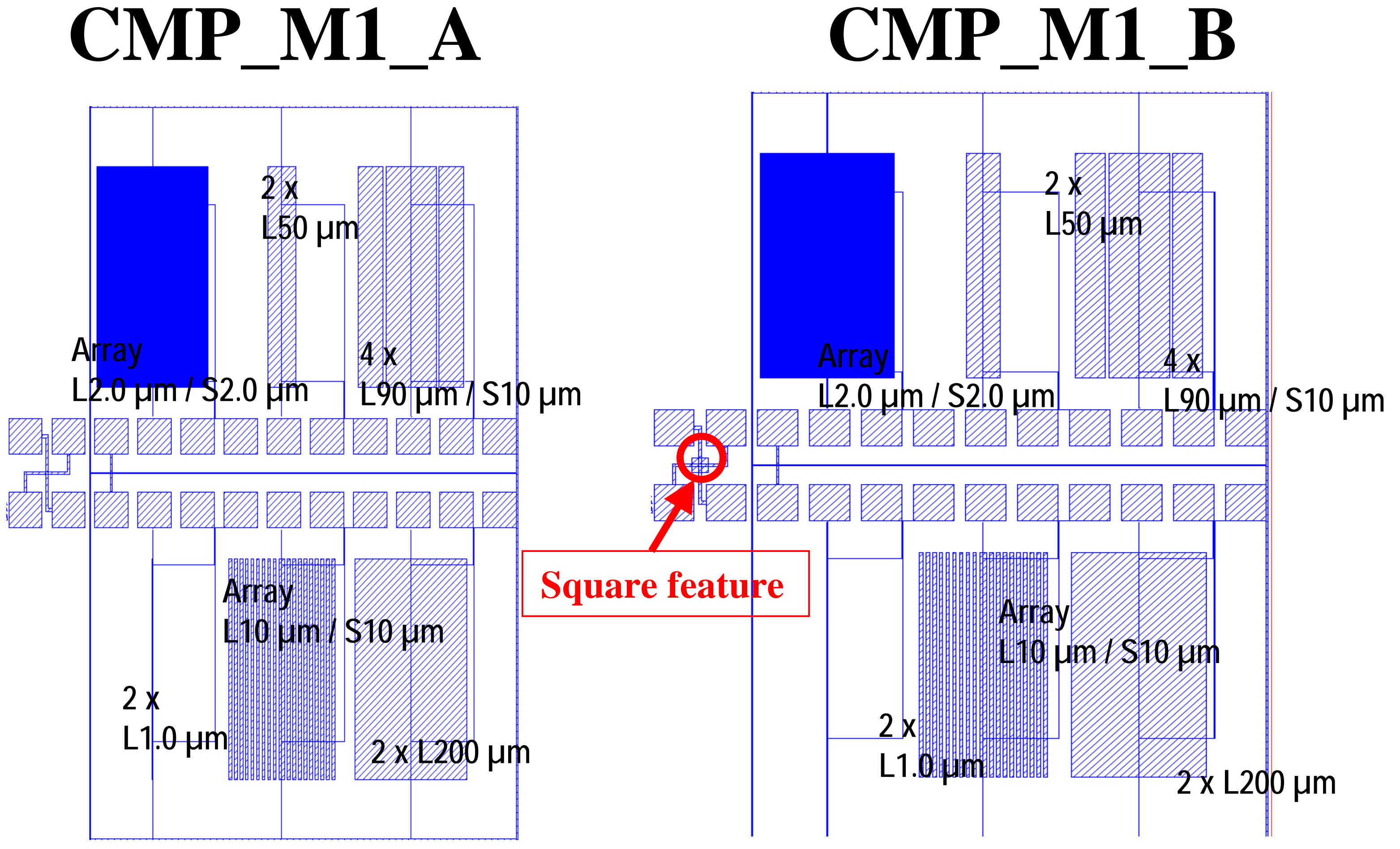
CMP Pads Row 2 Line Profile



CMP Pads Row 1 Line Profile



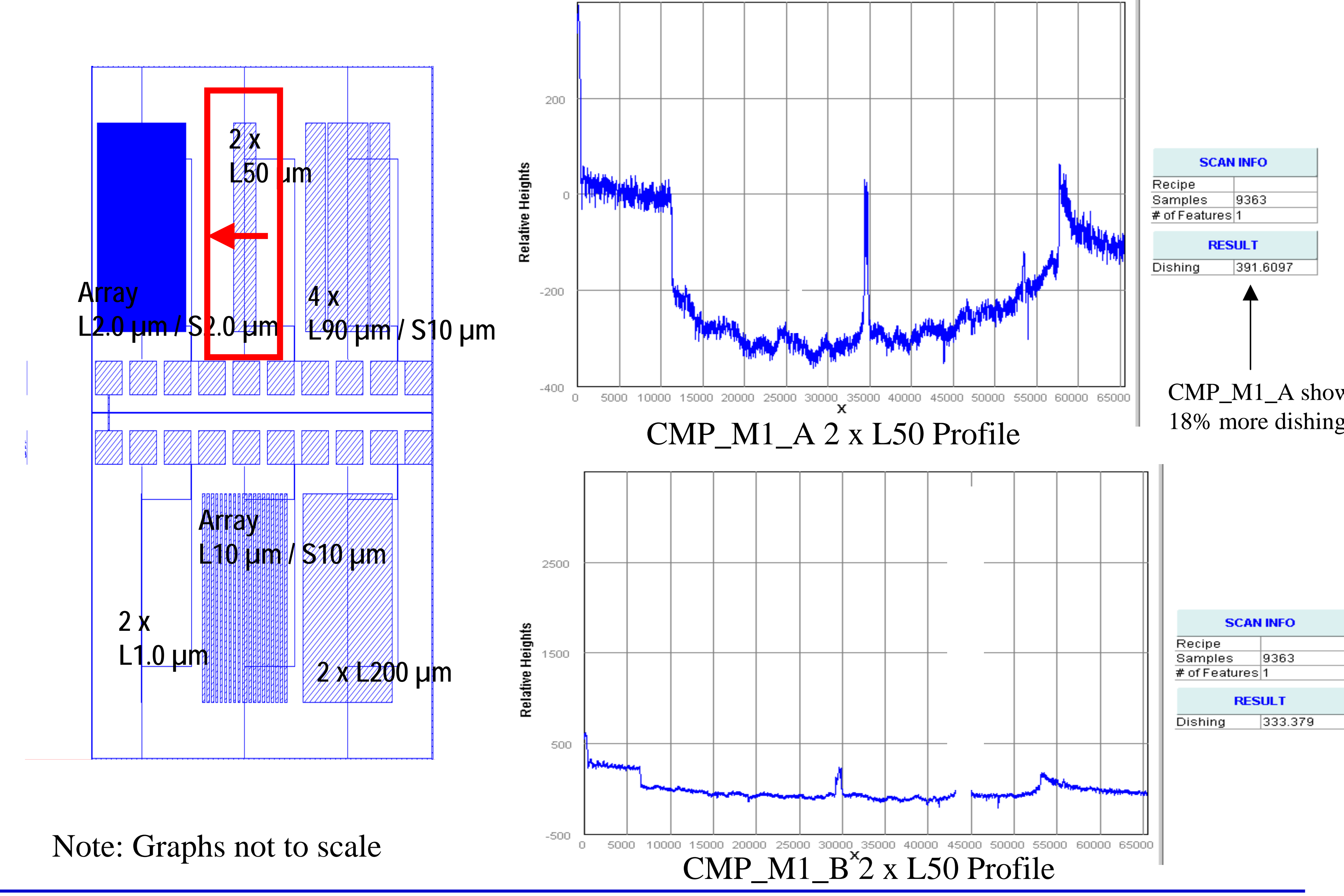
Array 1 Dish (A)	Array 1 CE (A)	Array 2 Dish (A)	Array 2 CE (A)	Array 3 Dish (A)	Array 3 CE (A)	Array 4 Dish (A)	Array 4 CE (A)
59	4	50	10	247	17	349	40



CMP_M1_B and CMP_M1_A have same array dimensions.

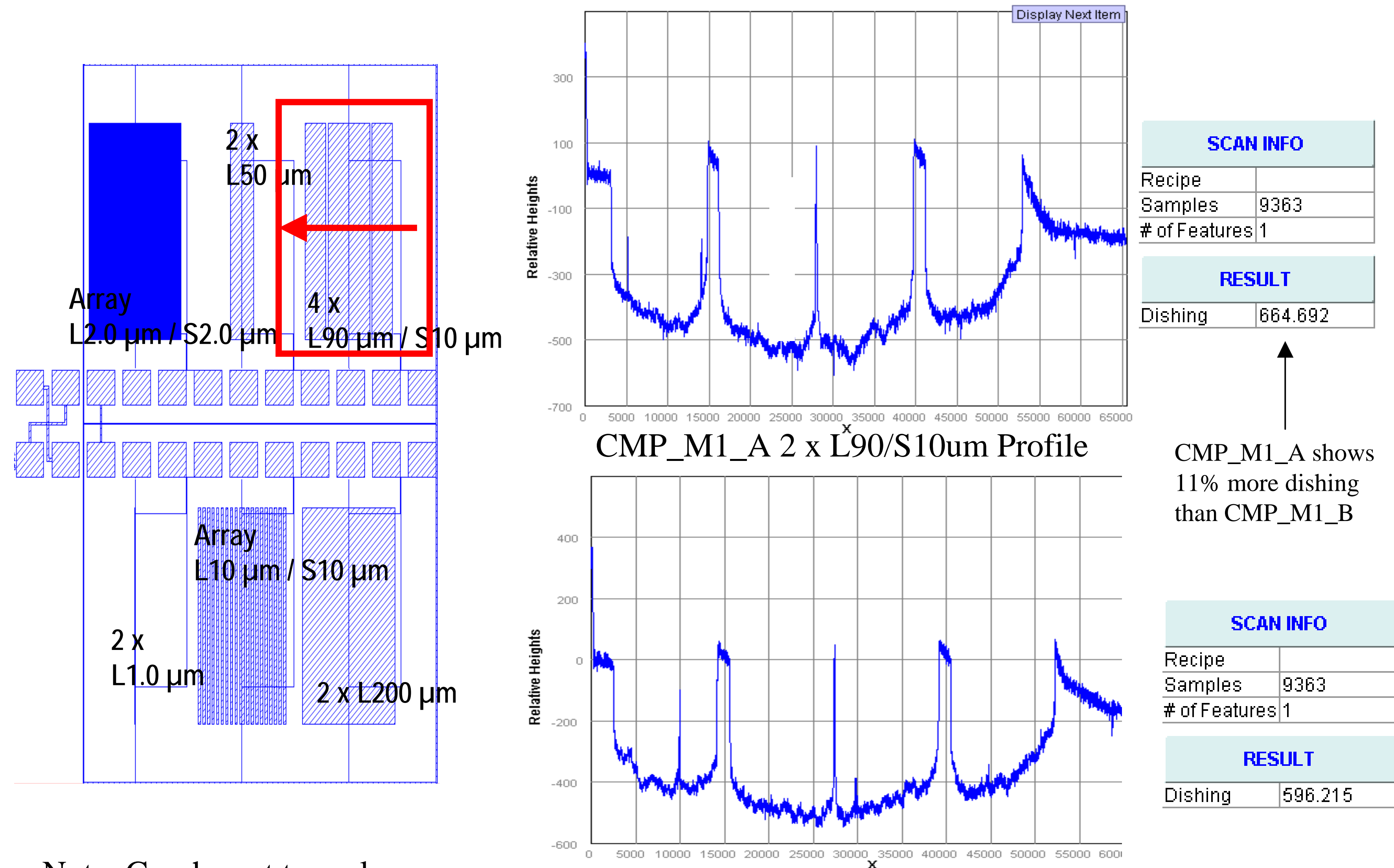
CMP_M1_B has a square feature, as is shown above, whereas CMP_M1_A does not. CMP_M1_A exhibits a greater amount of dishing after CMP, as is shown on the following pages.

2 x L50 um Structure



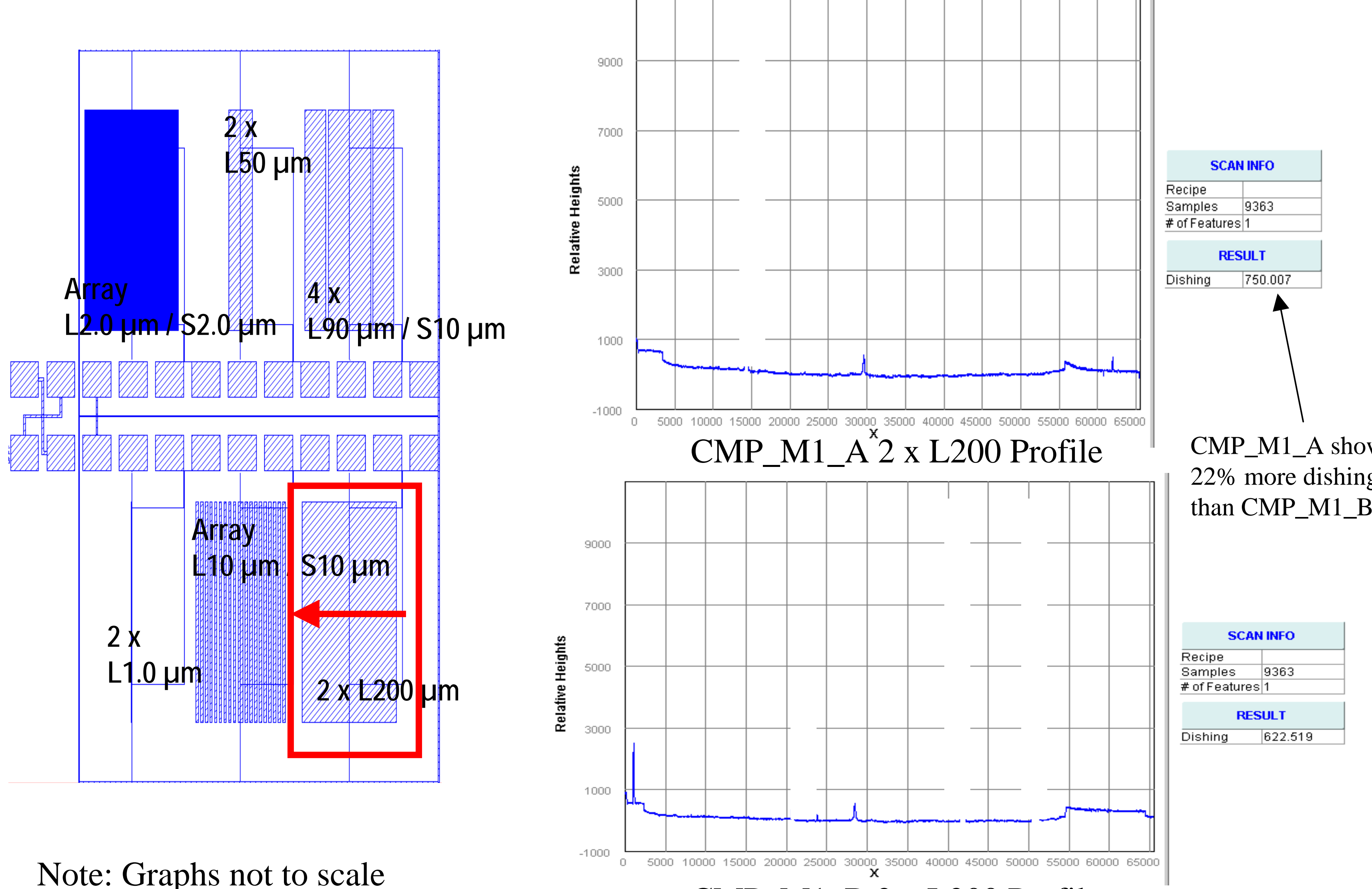
Note: Graphs not to scale

4 x L90 / S10 um Structure



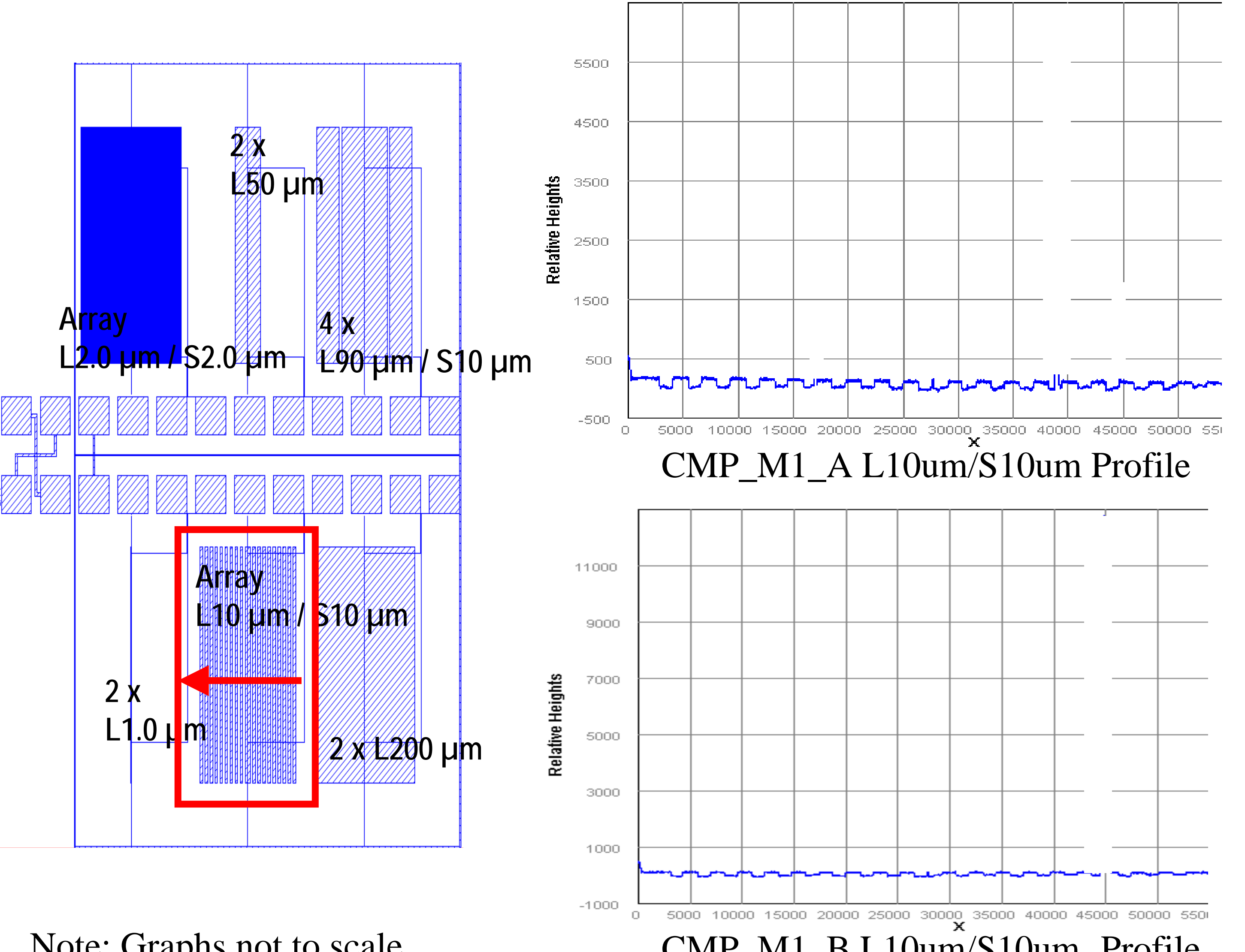
Note: Graphs not to scale

2 x L200 um Structure



Note: Graphs not to scale

L10 µm/ S10 µm Array Structure



SCAN INFO	
Recipe	
Samples	9363
# of Features	1

RESULT	
Dishing	184.424

CMP_M1_A shows 18% more dishing than CMP_M1_B

SCAN INFO	
Recipe	
Samples	9363
# of Features	1

RESULT	
Dishing	160.2173

Note: Graphs not to scale