DIRECT MEASUREMENT OF PLANARIZATION LENGTH FOR COPPER CHEMICAL MECHANICAL POLISHING (CMP) PROCESSES USING A LARGE PATTERN TEST MASK.

Paul Lefevre, Albert Gonzales, Tom Brown, Gerald Martin,International SEMATECH, Austin, TX;
Tamba Tugbawa, Tae Park, Duane Boning, Microsystems Technology Laboratories, MIT, Cambridge, MA;
Michael Gostein, Philips Analytical, Natick, MA;
John Nguyen, SpeedFam-IPEC, Phoenix, AZ.

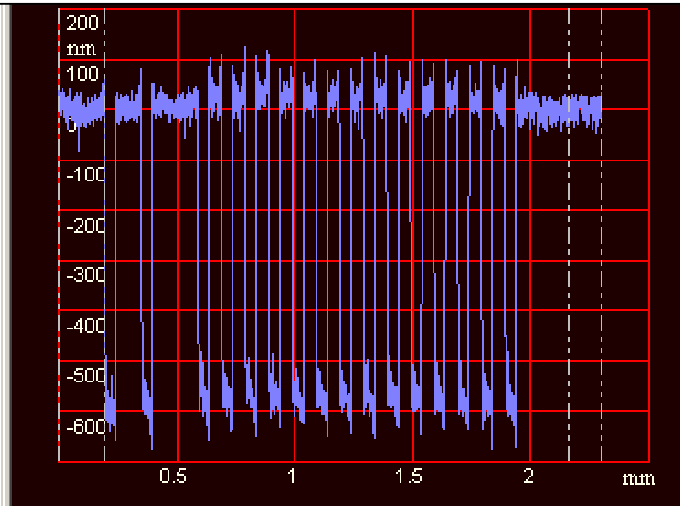
Agenda

- Introduction
- Pre CMP topography
- International Sematech / MIT Mask 862 design
- Wafer process and metrology
- Planarization Length definition
- Planarization Length on different process
- Planarization Length on different consumables
- Conclusion

Introduction

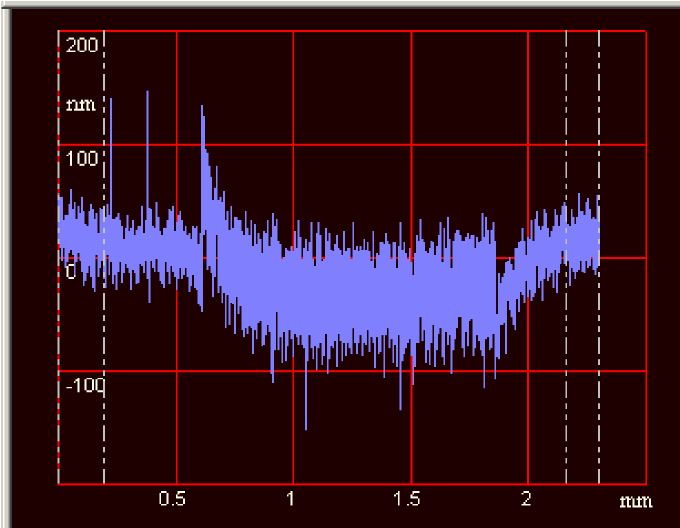
- Visual observation copper residue are more or less pattern dependent (Qualitative)
- Feature size design / Pre CMP topography size
- Develop a direct qualitative method for planarization distance measurement.
- Help industry with having access to this mask International Sematech / MIT 862 (Semiconductor and CMP suppliers)

Pre CMP topography



50 um copper line, 50 um space

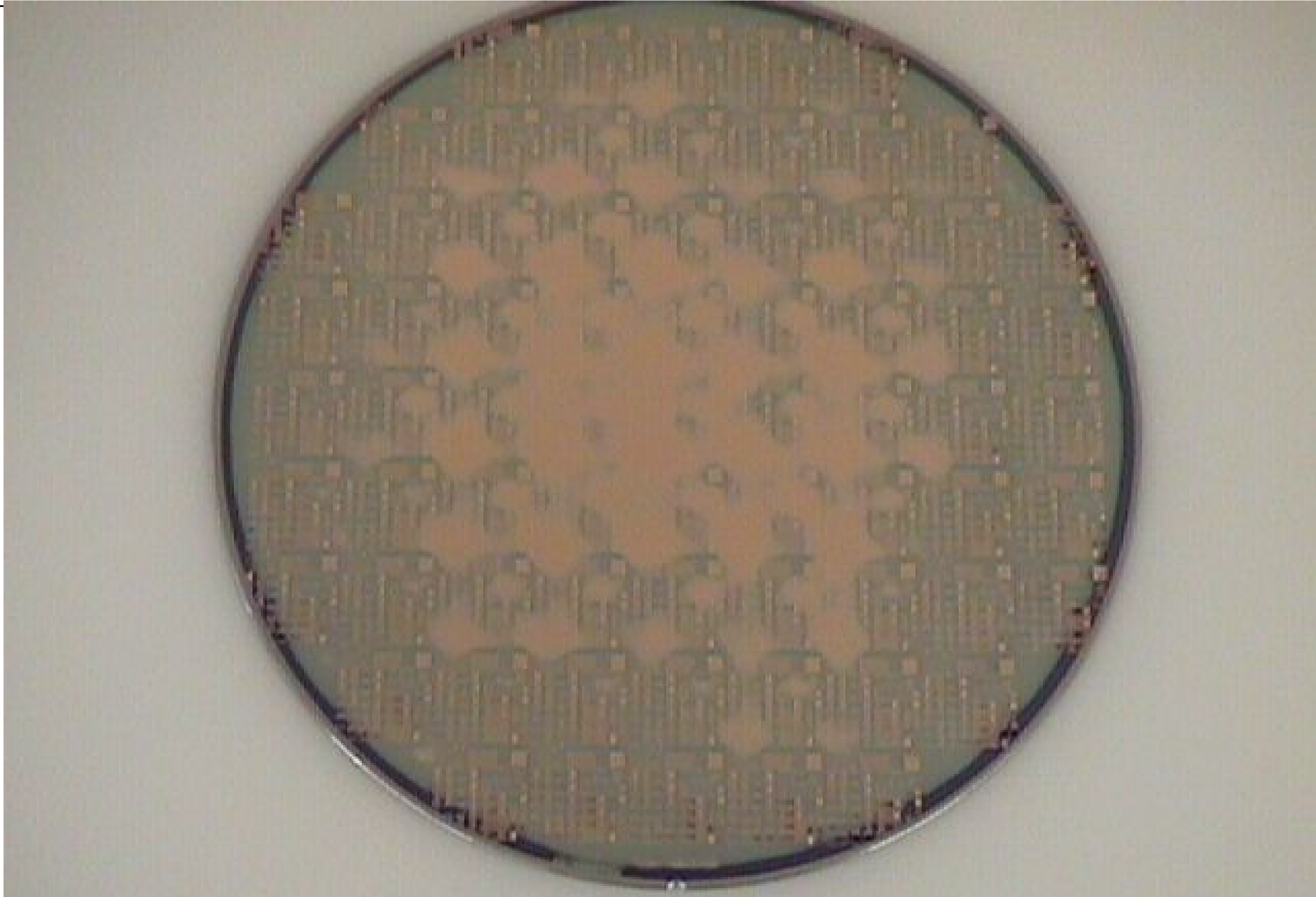
0.25 um copper line, 0.25 um space



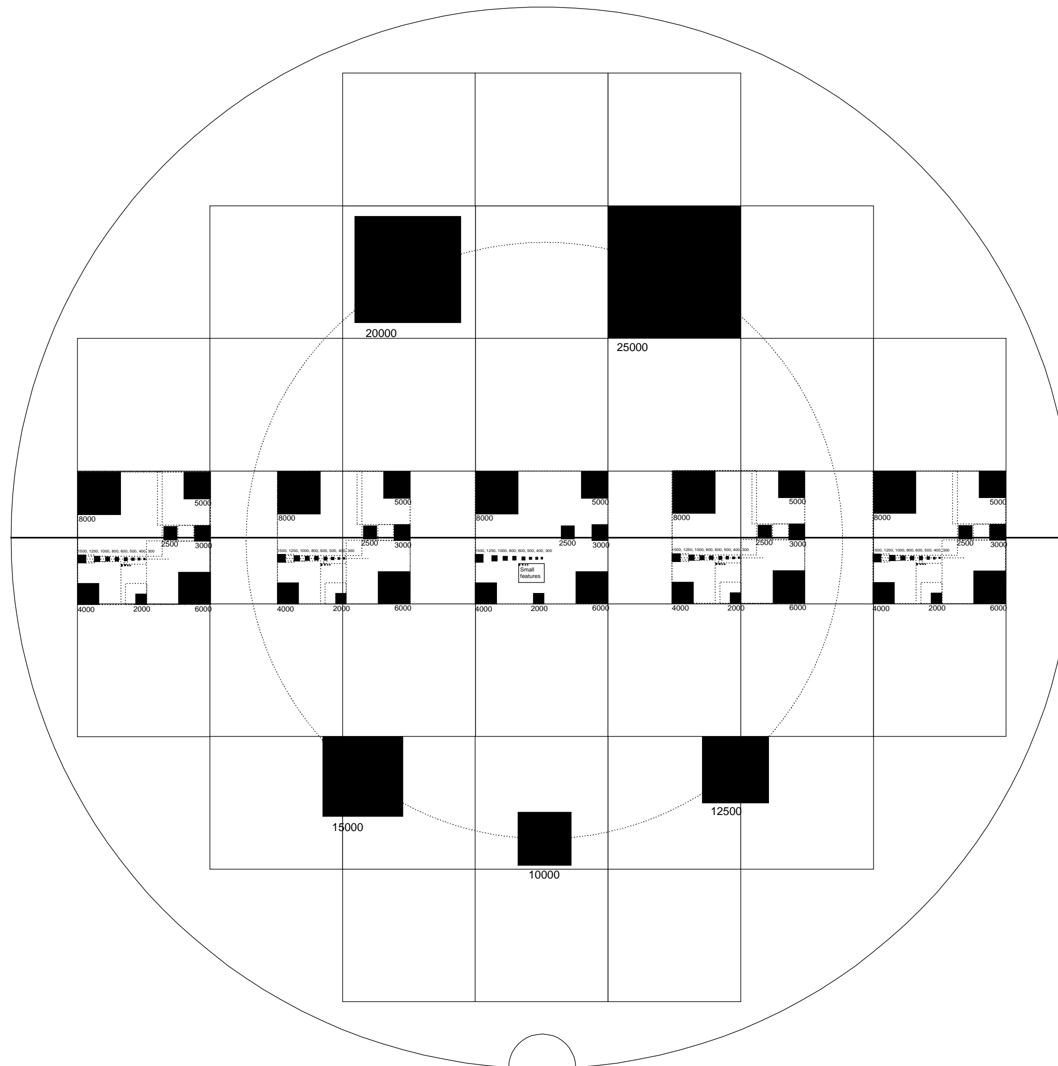
1 um copper line, 1 um space

9 um copper line, 1 um space

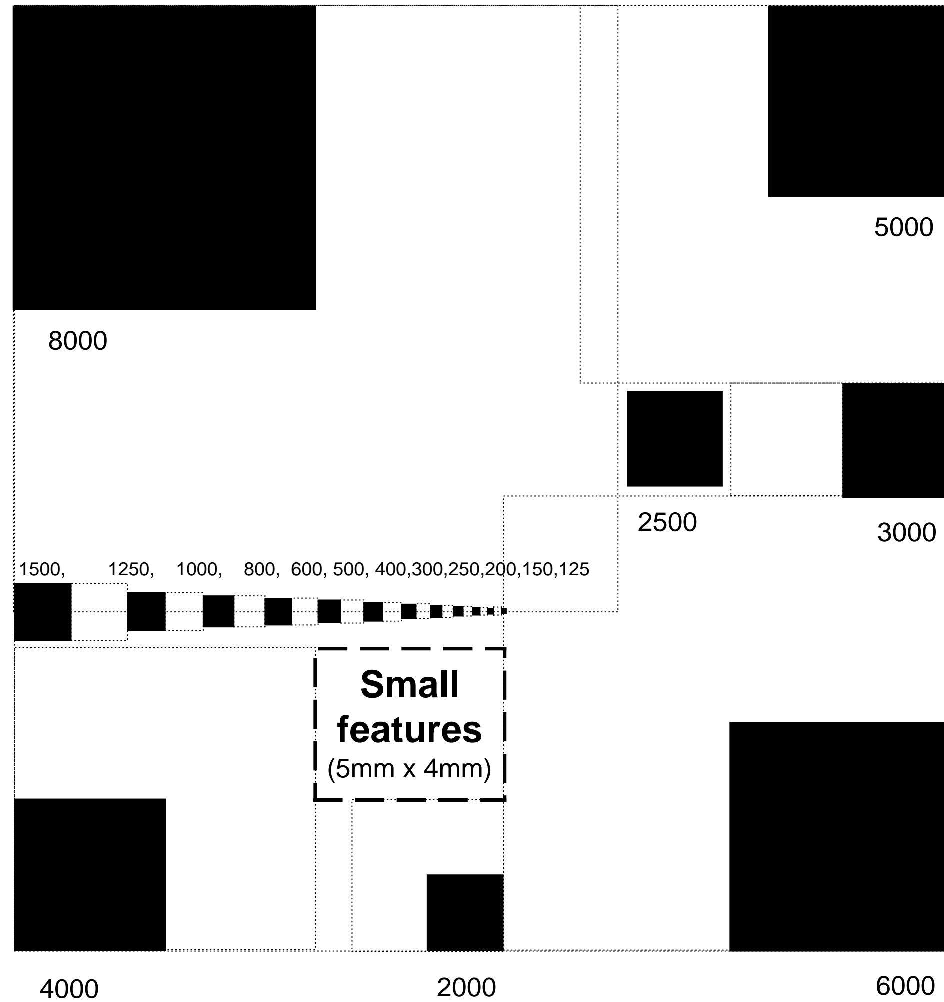
Pre CMP topography consequence



Wafer layout

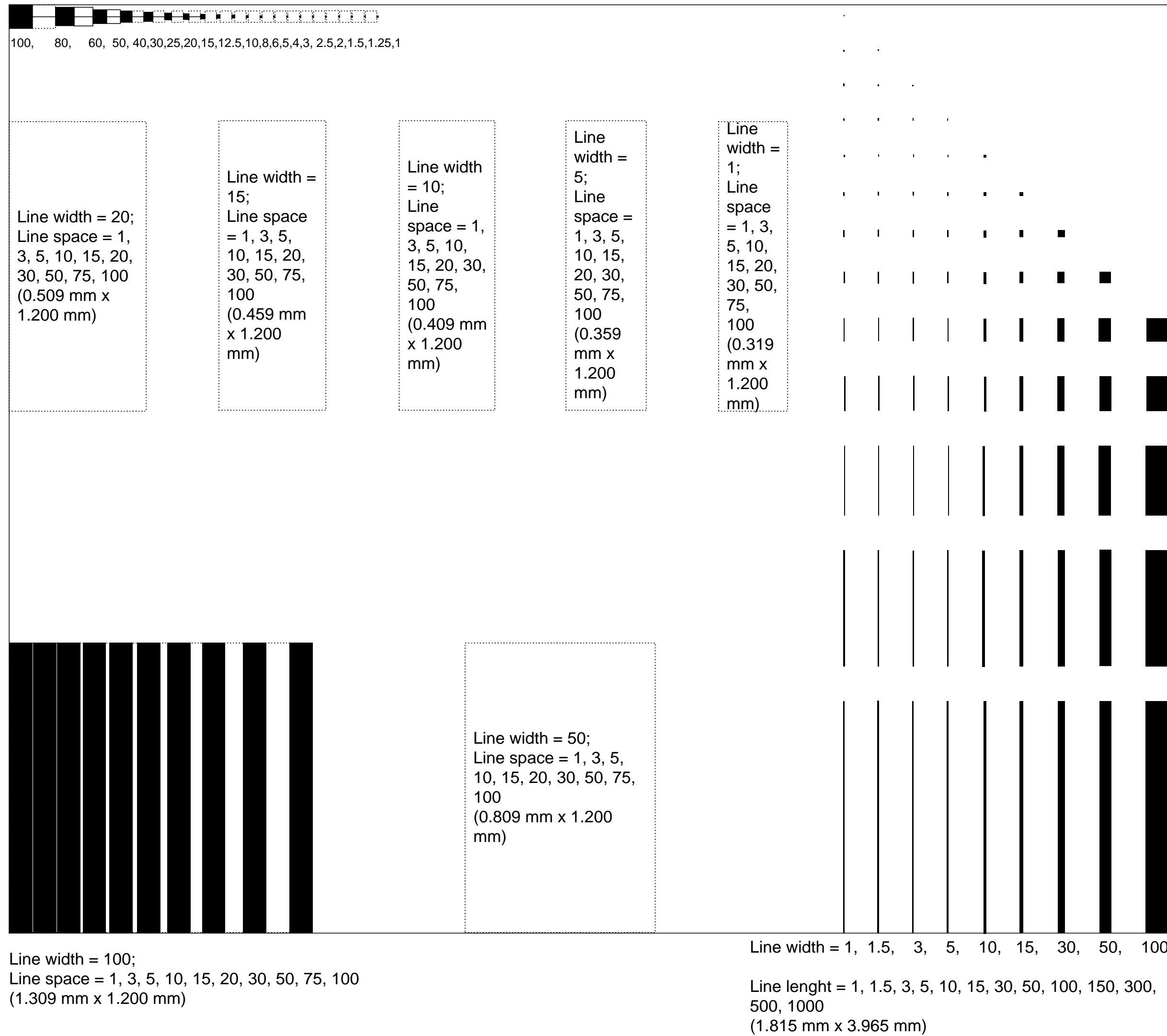


Mask layout

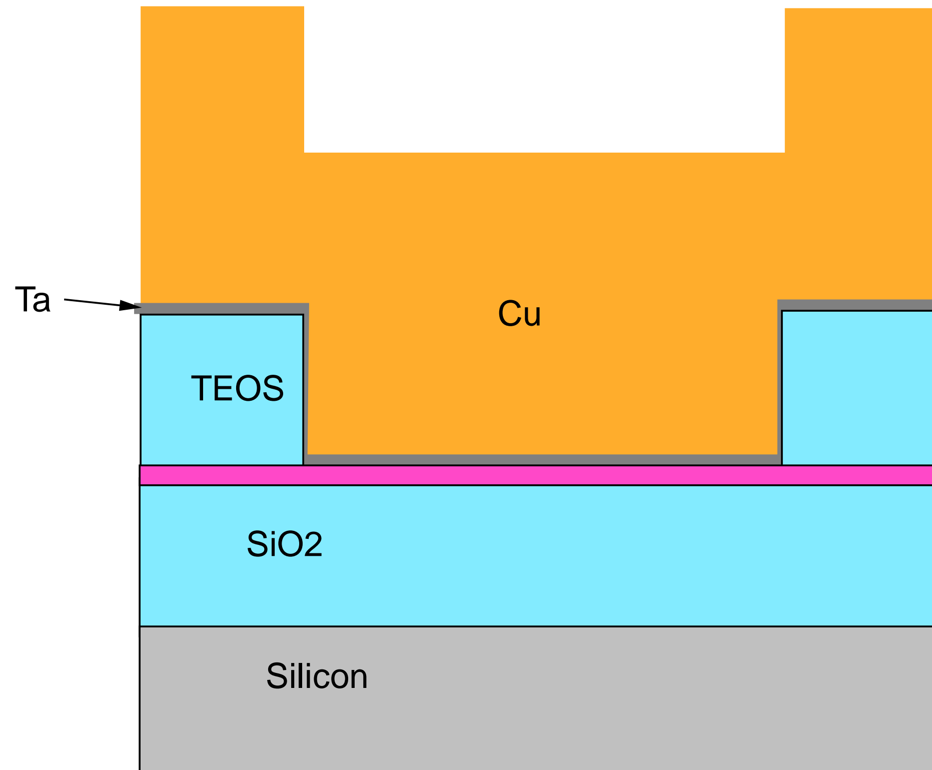


Small structures

Small features
(5mm x 4mm)



Wafer process

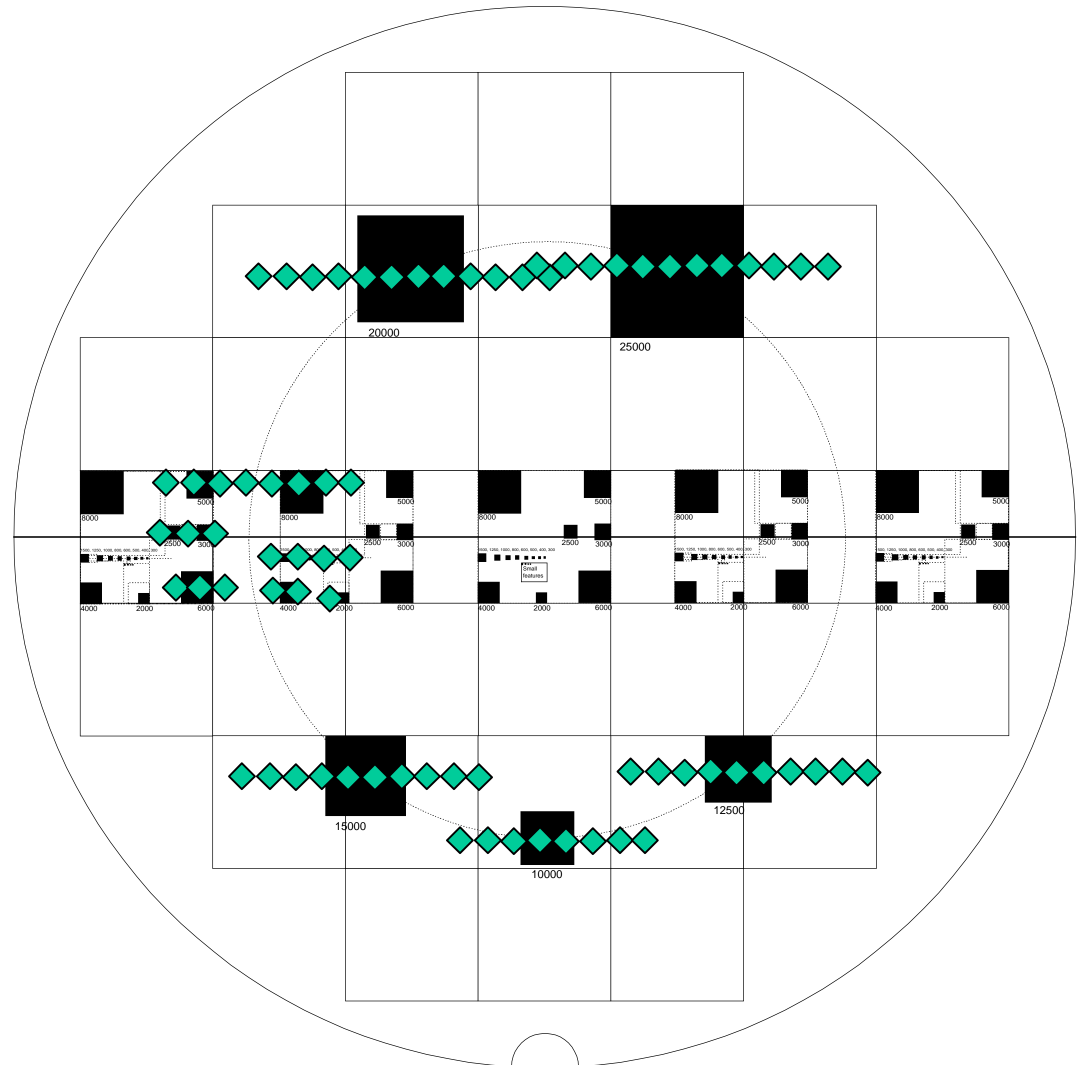


Copper Thickness is 2X trench height

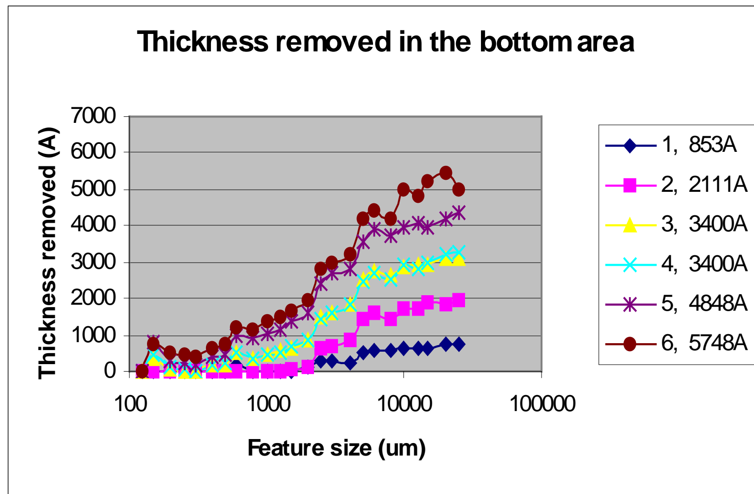
Metrology

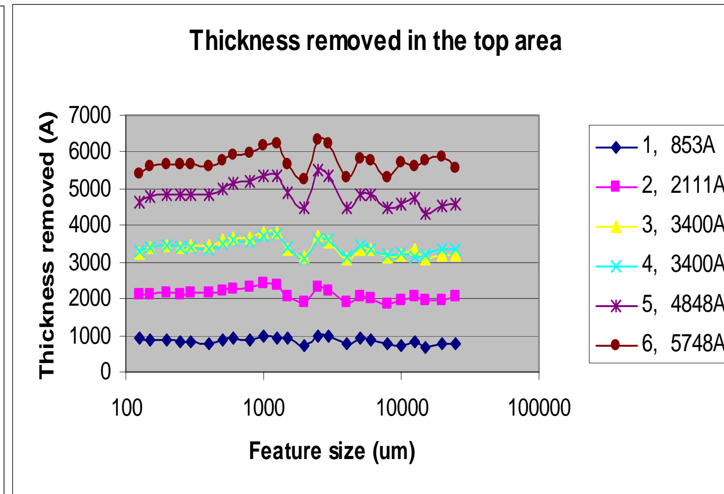
Measurements performed on Philips Impulse 300

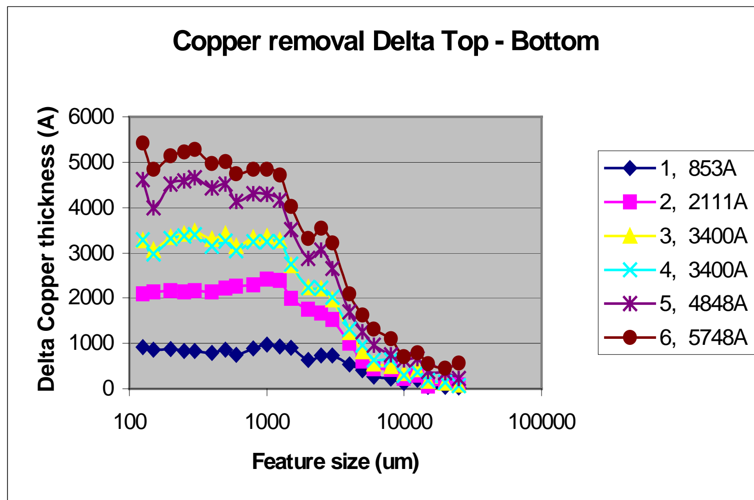
15 measures per Structure
-5 left
-5 center
-5 right

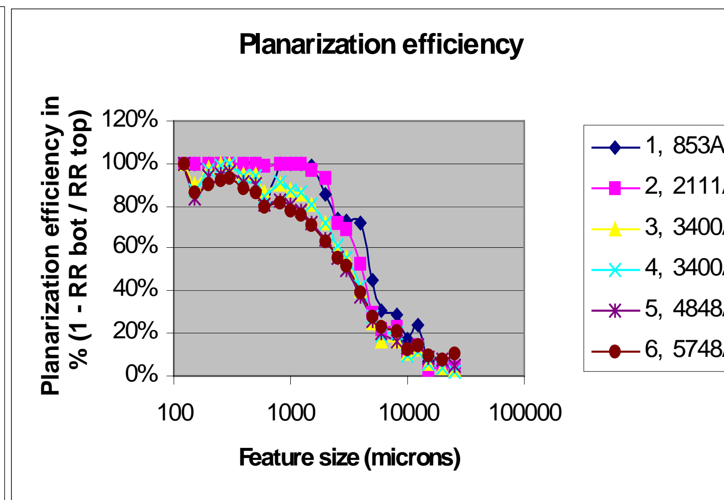


Results





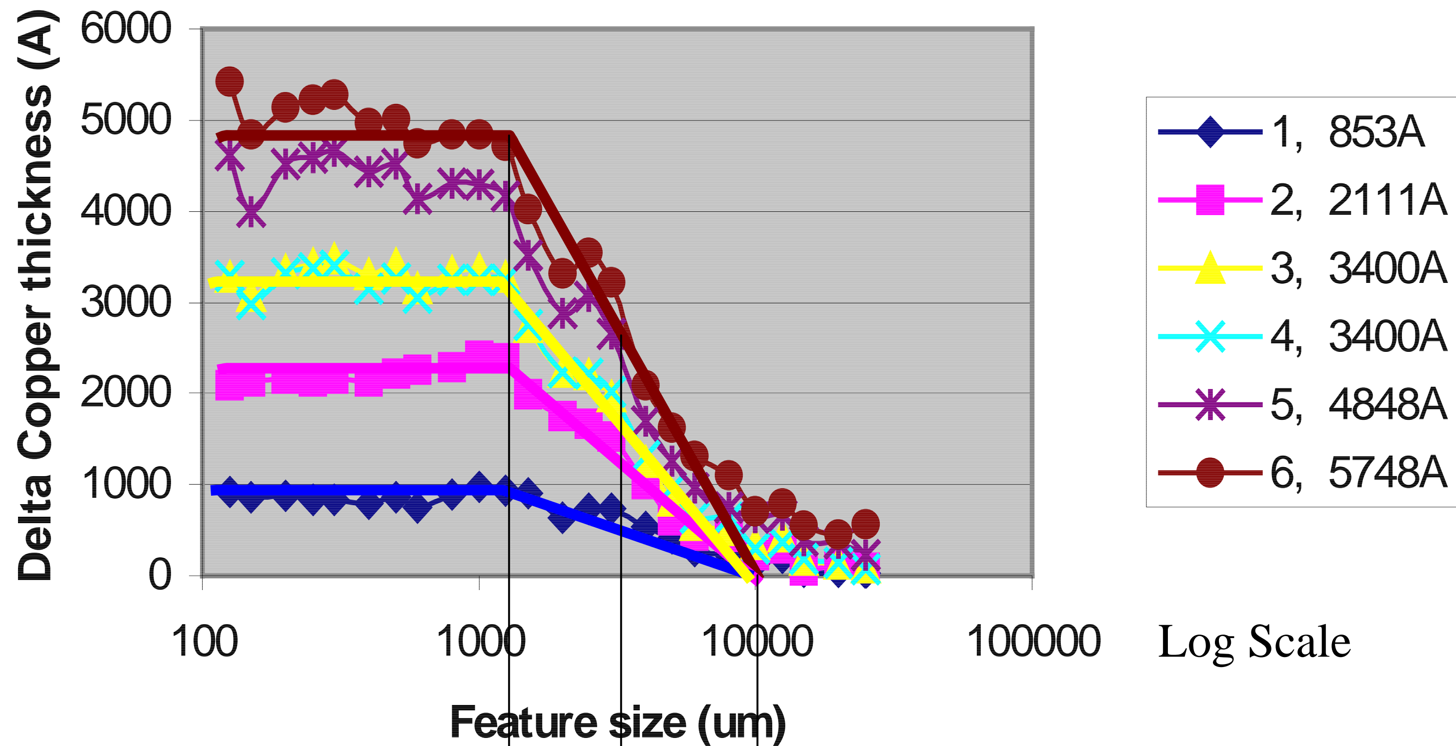




Top - Bottom

PE = 1 – Bottom / Top

Results



Planarization Lengths
Average Planarization Length

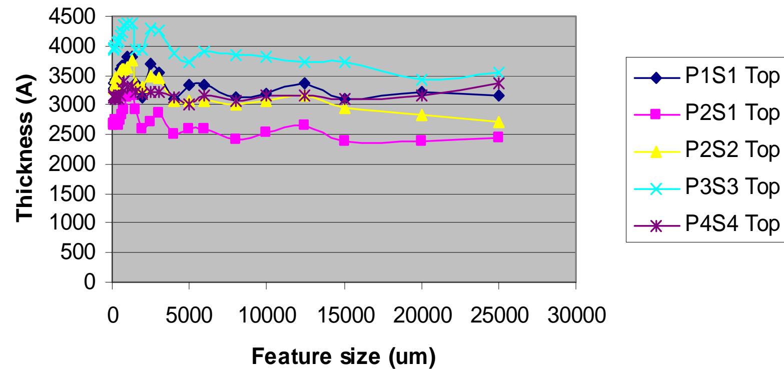
Maximum Planarization Length = Minimum Feature size were removal bottom equal removal top
Or
Maximum Planarization Length = Minimum Feature size were planarization Efficiency is zero

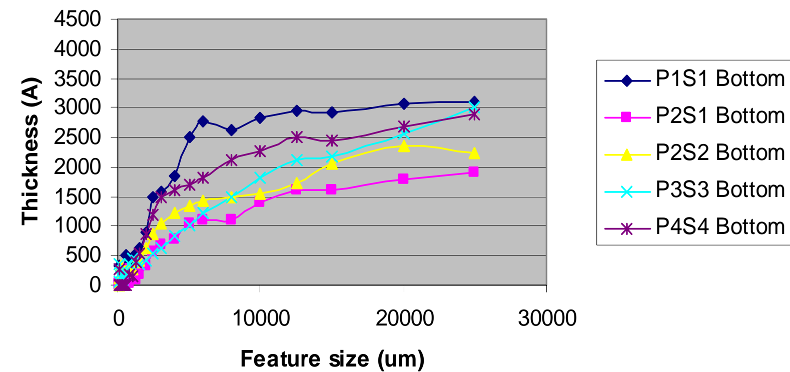
Minimum Planarization Length = Maximum Feature size where removal bottom is zero
Or
Minimum Planarization Length = Maximum Feature size where planarization efficiency is 1

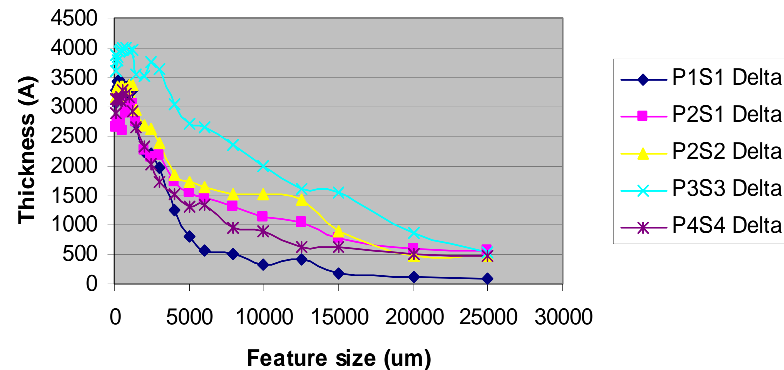
Average Planarization Length on a Log scale diagram is = Exp (Average (Min PL, Max PL))

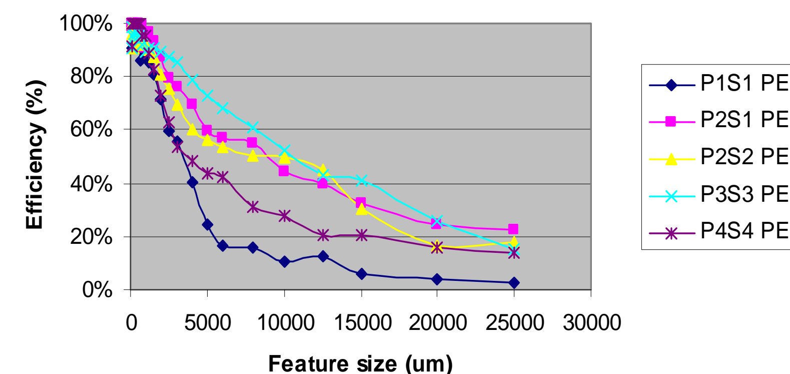
Average planarization Length = $\sqrt{(\text{Min PL}) \times (\text{Max PL})}$

Consumable comparison

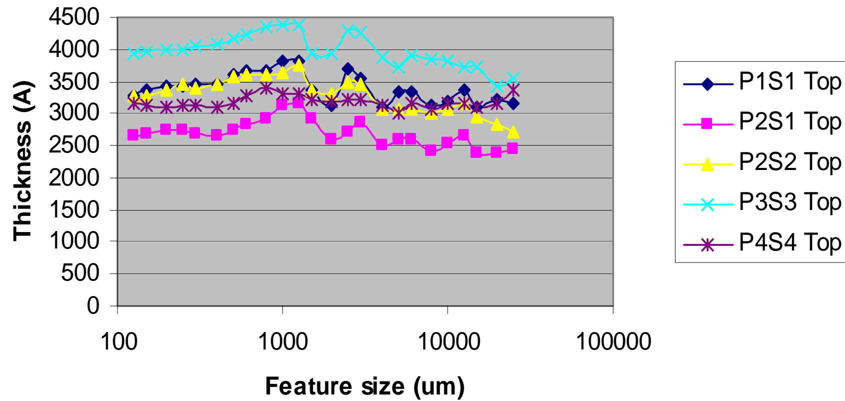


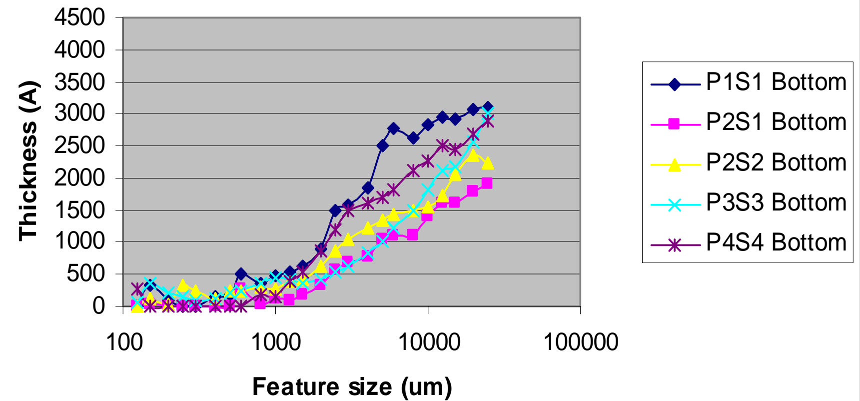


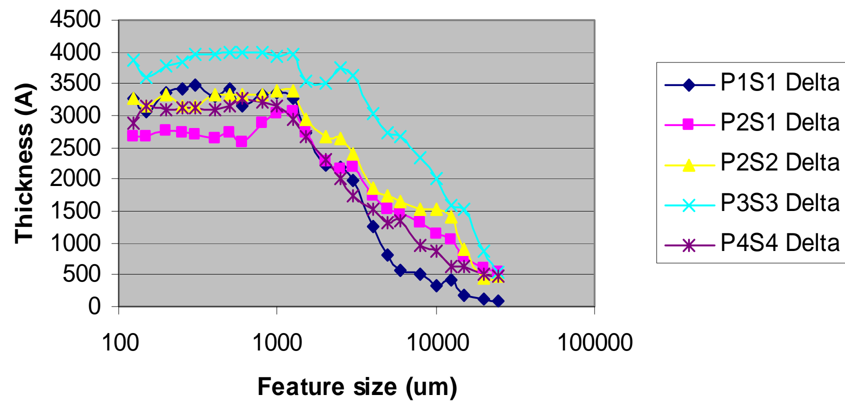


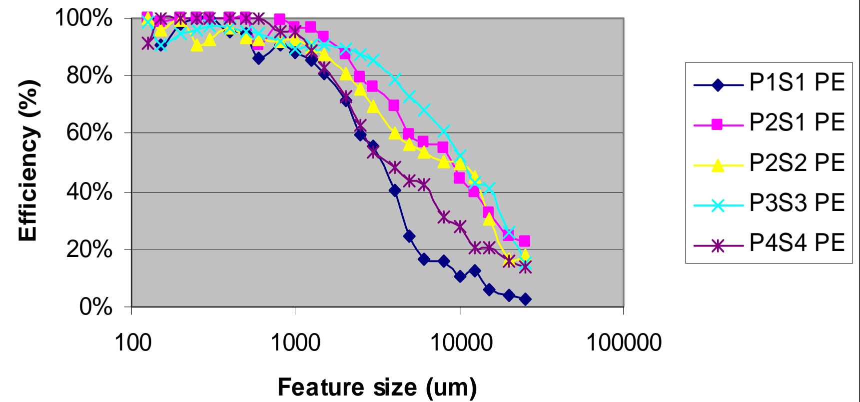


Consumable comparison





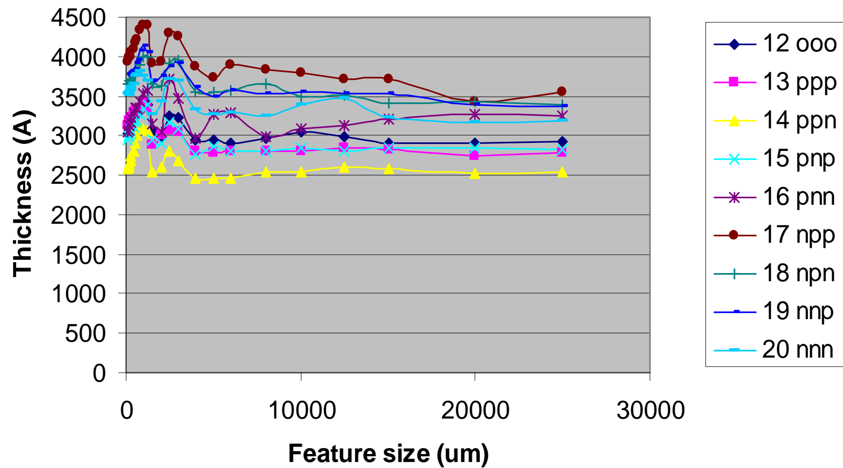


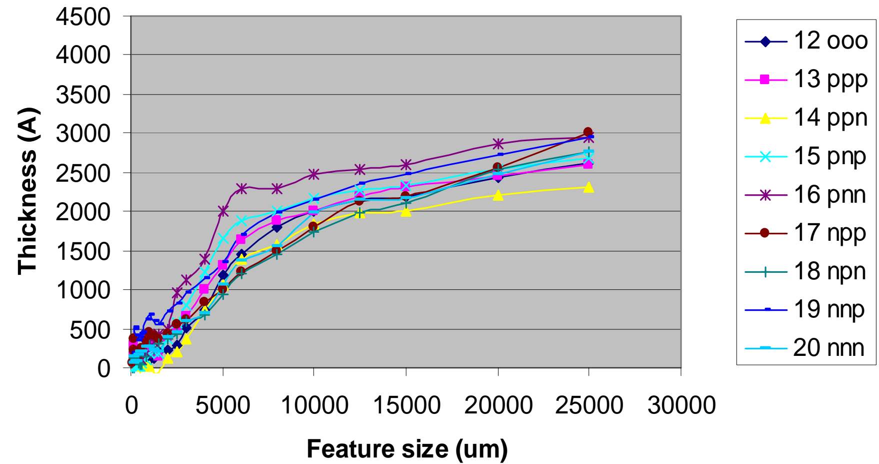


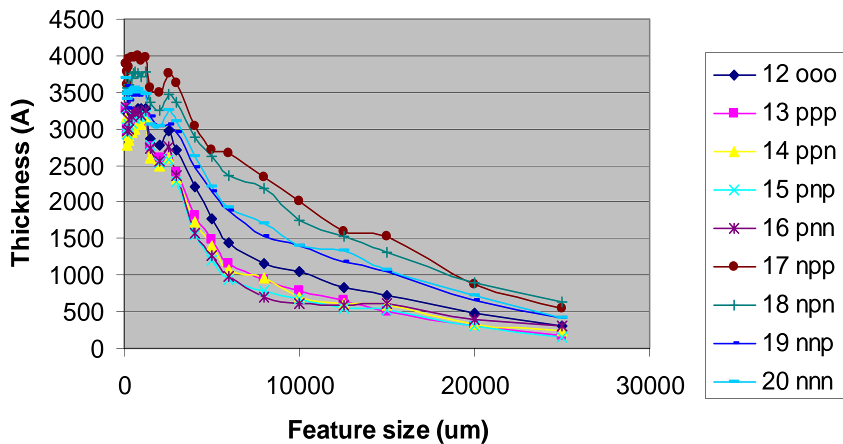
Consumable comparison

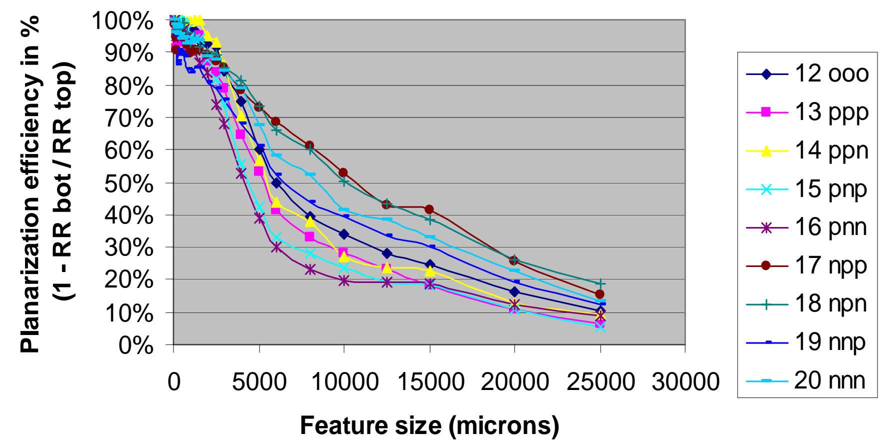
Process Symbol	Down Force (psi)	Carrier Speed (rpm)	Table Speed (rpm)	Slurry Type	Pad Type	Tool Type	Max PL (um)	Min PL (um)	Av. PL (um)
P1S1	4	75	75	A	Stacked	Rotary	9000	1250	3354
P2S1	4	75	75	A	Solo	Rotary	28000	1250	5916
P2S2	4	75	75	B	Solo	Rotary	39690	1250	7044
P3S3	2	100	100	C	Stacked	Rotary	39690	2000	8910
P4S4				D	Solo**	Orbital	50009	1000	7072

Process comparison

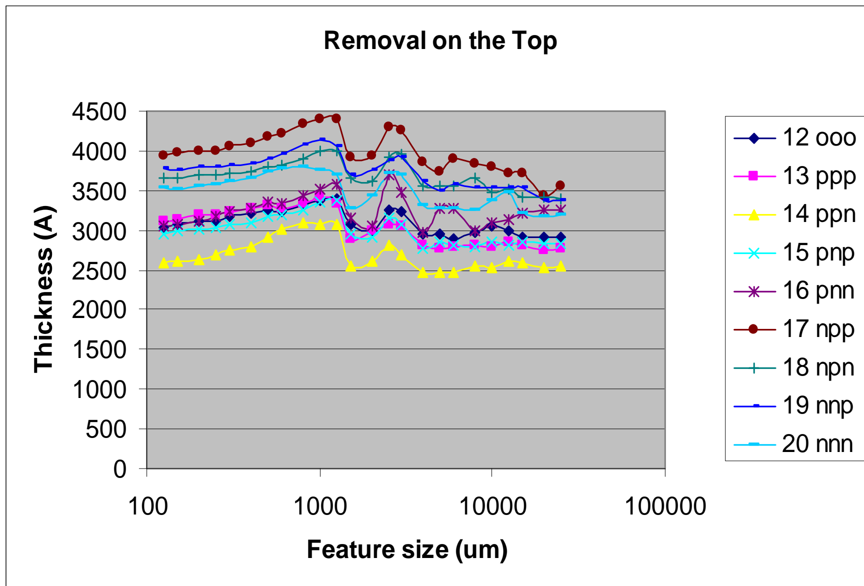


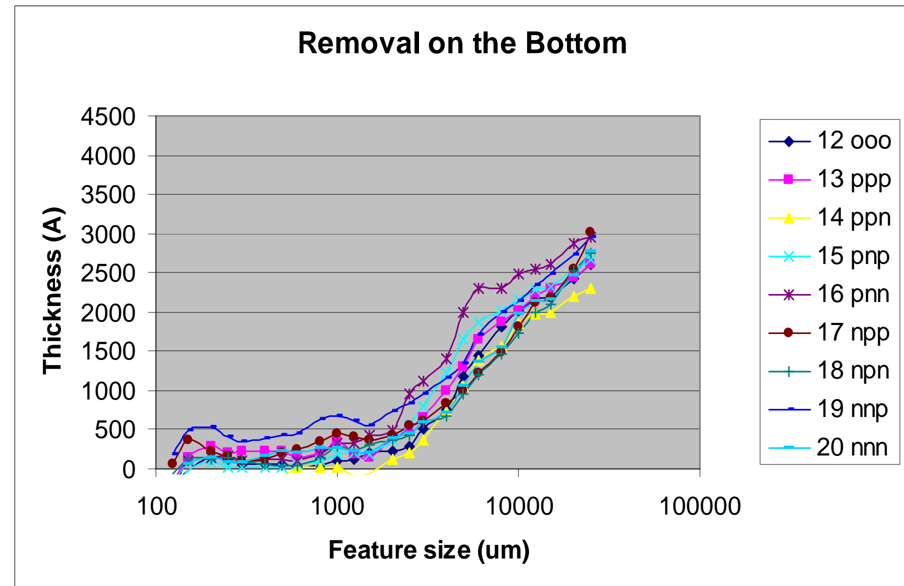


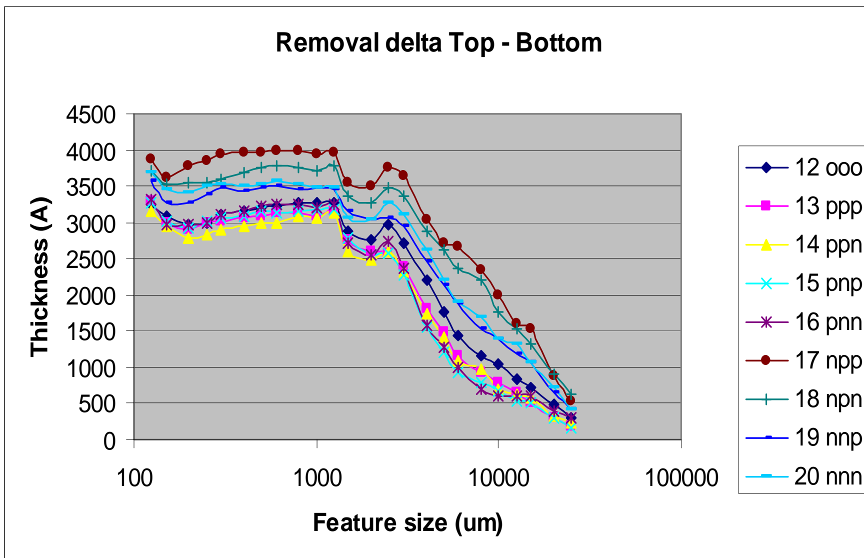


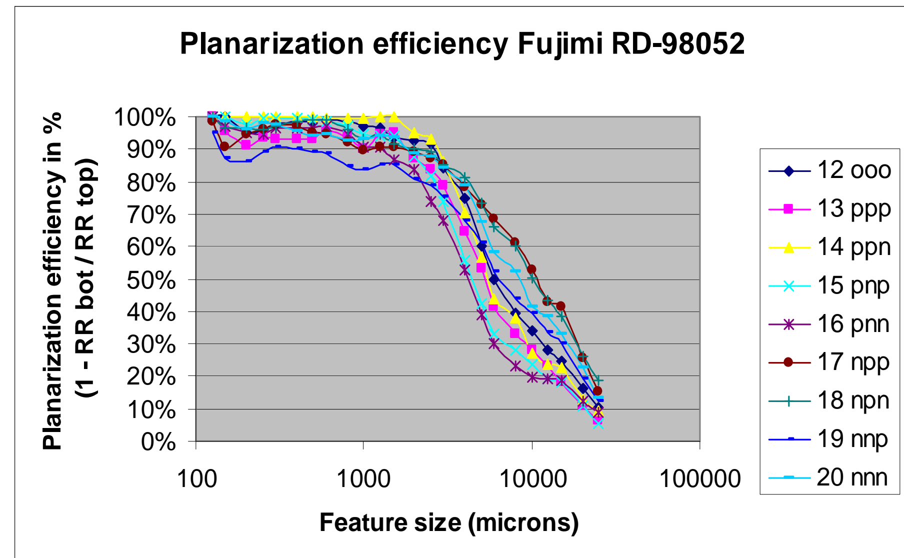


Process comparison





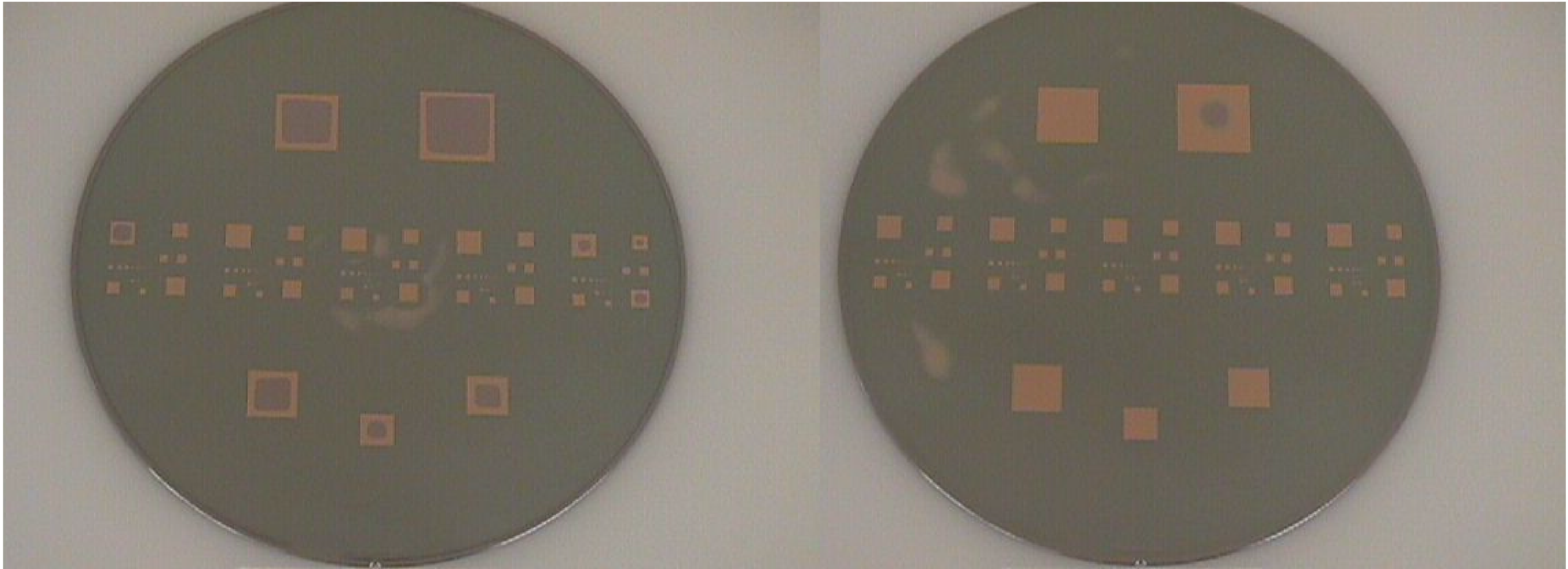




Process comparison

Process Symbol	Down Force (psi)	Carrier Speed (rpm)	Table Speed (rpm)	Slurry flow (ml/min)	Slurry Type	Pad Type	Tool Type	Max PL (um)	Min PL (um)	Av. PL (um)
ooo	2	65	65	125	C	Stacked	Rotary	20000	2000	6325
ppp	3	100	100	200	C	Stacked	Rotary	12500	2000	5000
ppn	3	100	100	50	C	Stacked	Rotary	12500	2000	5000
pnp	3	30	30	200	C	Stacked	Rotary	8000	2000	4000
pnn	3	30	30	50	C	Stacked	Rotary	8000	2000	4000
npp	1	100	100	200	C	Stacked	Rotary	39375	3000	10869
npn	1	100	100	50	C	Stacked	Rotary	39375	3000	10869
nnp	1	30	30	200	C	Stacked	Rotary	39375	2500	9922
nnn	1	30	30	50	C	Stacked	Rotary	39375	2500	9922

Process comparison



Low Planarization Length | Very high Planarization Length

Conclusion

- New International Sematech / MIT mask 862 allow a direct measure of planarization Length
- Definition of Planarization Length
- Wafers mask 862 available – In public domain