Surface MEMS Fabrication Details

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10-30-2014 SurfaceMEMsFabricationDetails.ppt

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OUTLINE

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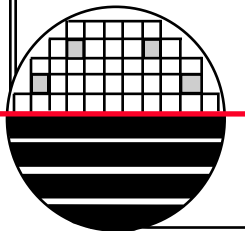
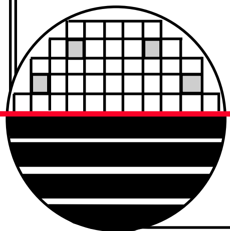


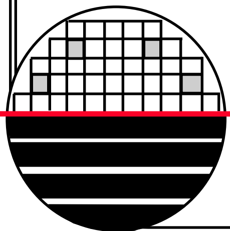
INTRODUCTION

This document provides detailed information on RIT's surface micromachine process. This process is capable of making many different types of MEMS devices. This MEMS fabrication process is CMOS compatible (with some modifications) back end module that can be added to realize compact microsystems (CMOS plus MEMS).

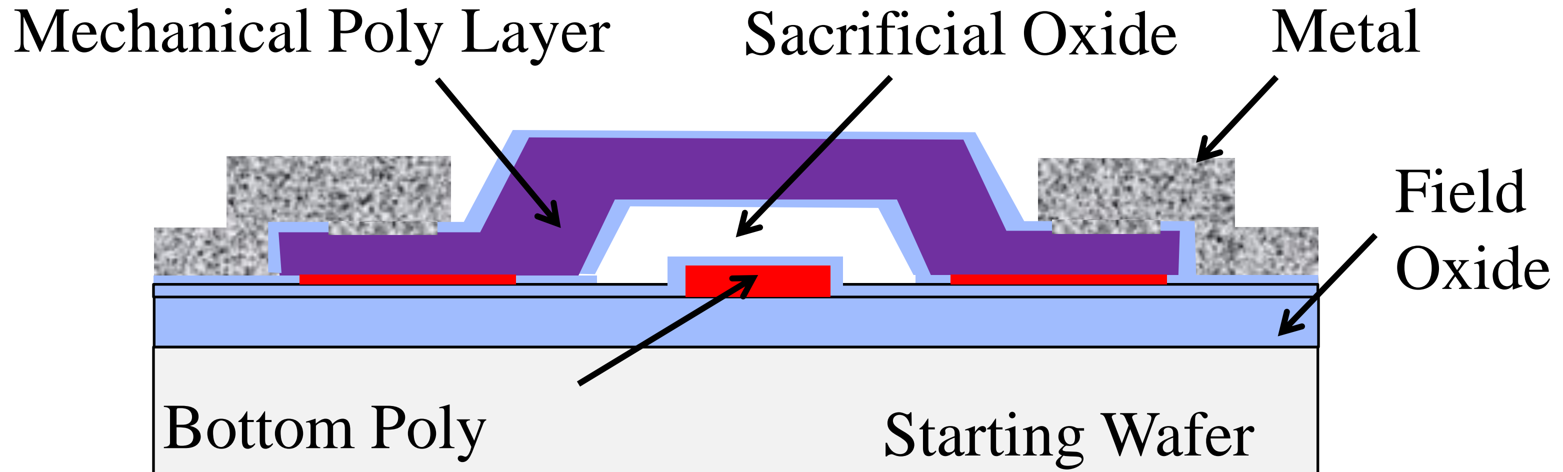


LIST OF MEMS DEVICES MADE WITH THIS PROCESS

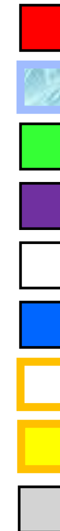
Resistors – Micro Bolometer
Heaters – Chemical Sensors
Micro Mirror - Two Axis Mirror
Thermally Actuated Two Arm Cantilever
Chevron Actuators
Electrostatic Comb Drive
MEMS Switch
Accelerometer
Gas Flow Sensor, Anemometer, Thermionic
Light Modulator
Bio Probes
Speaker
Humidity Sensors
Pressure Sensors - Microphone
Temperature Sensors – Thermopile, Resistor
Inductors, Capacitors – Humidity Sensor
Hall Effect Sensors – other Magnetic Field Sensors

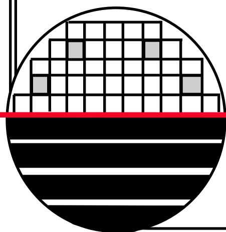


DEVICE CROSS SECTION



Bottom Poly 1 (Red) Layer 1
Sacrificial Oxide (Blue Outline) Layer 2
Anchor (Green) Layer 3
Mechanical Poly 2 (Purple) Layer 4
Contact Cut (White) Layer 6
Metal (Blue) Layer 7
Outline (Yellow Outline) Layer 9
No Implant Yellow Layer 15
Holes Layer 16 (combined with Poly 2)



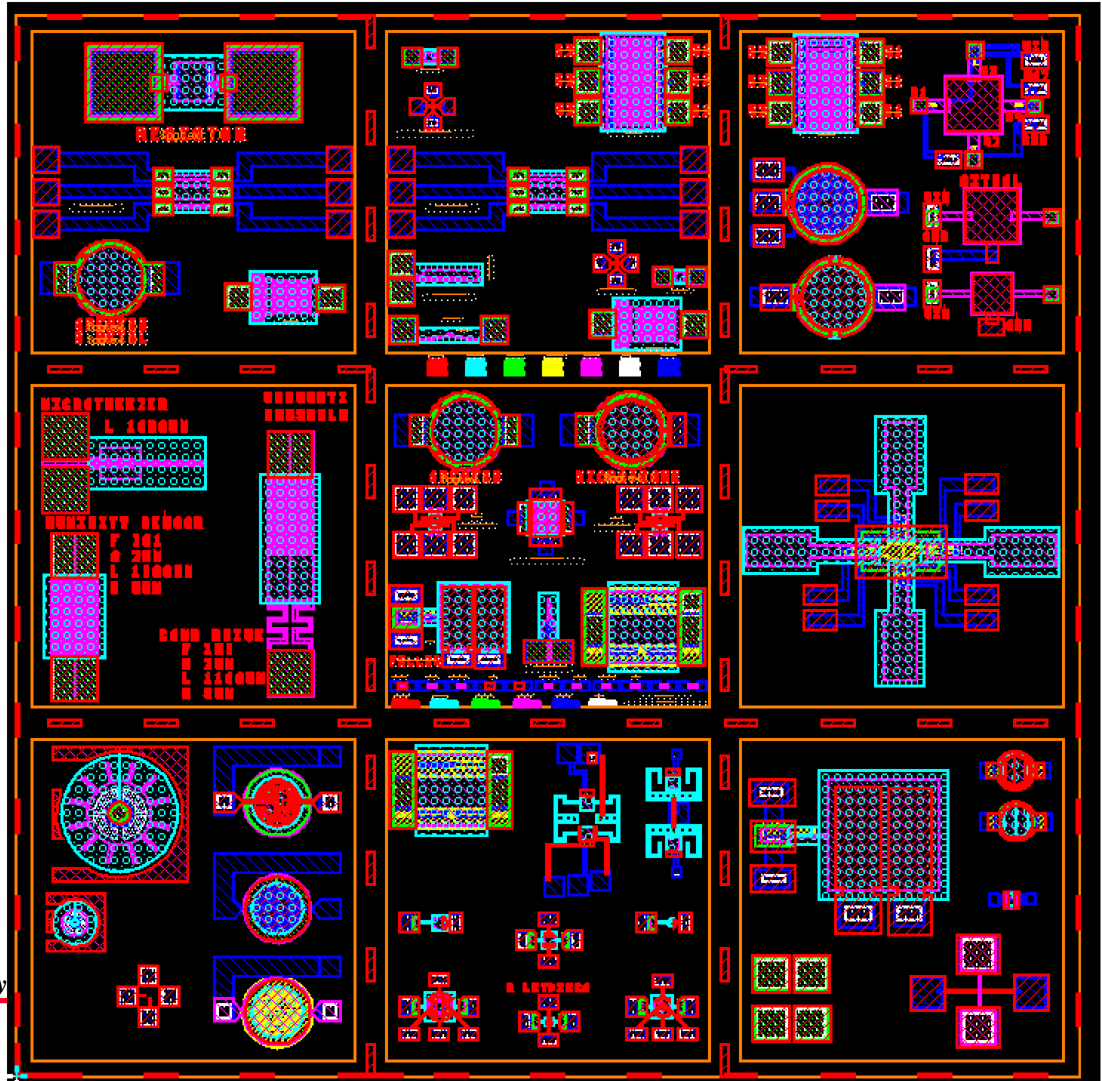


2014 MEMS MULTICHIP PROJECT DESIGN

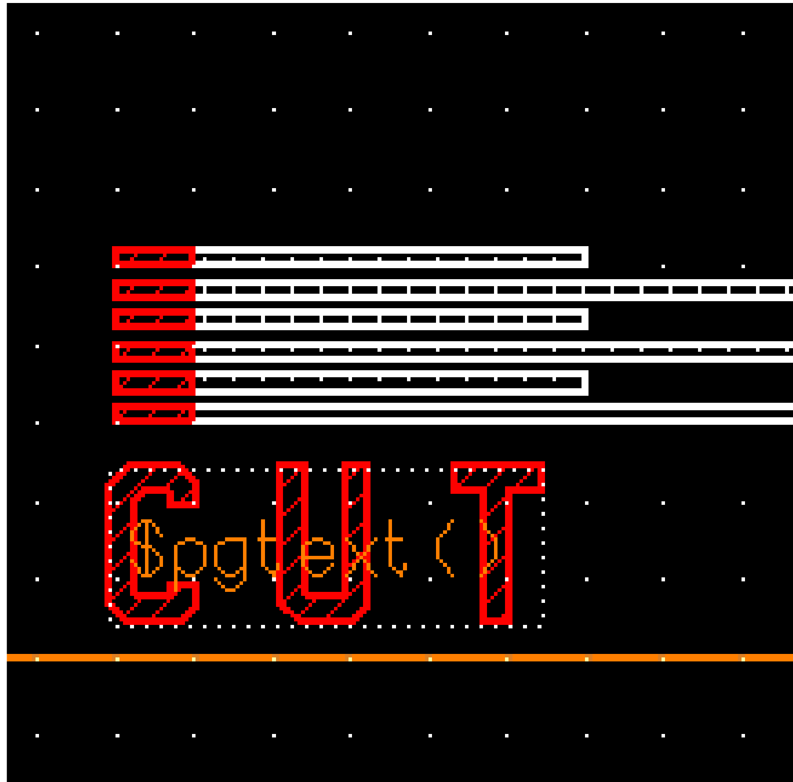
Total 15 mm by 15 mm plus 500 um for sawing into 9 chips for overall 16.5mm by 16.5mm size.

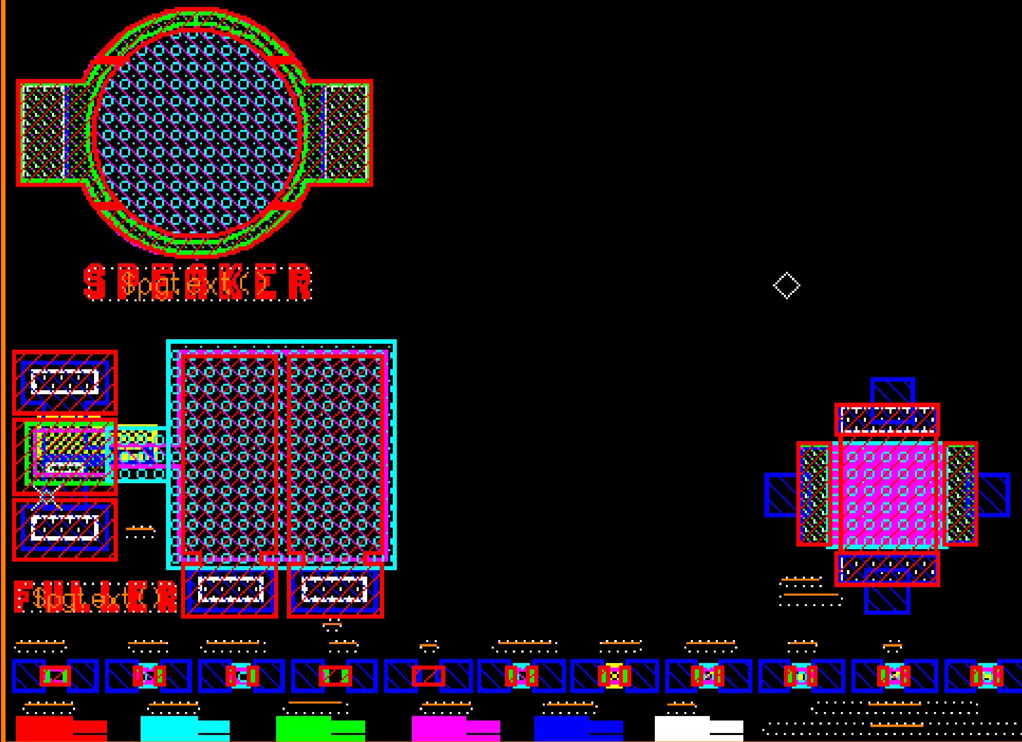
Wafer sawing is easier if all chips are the same size

5mm by 5mm design space for each project



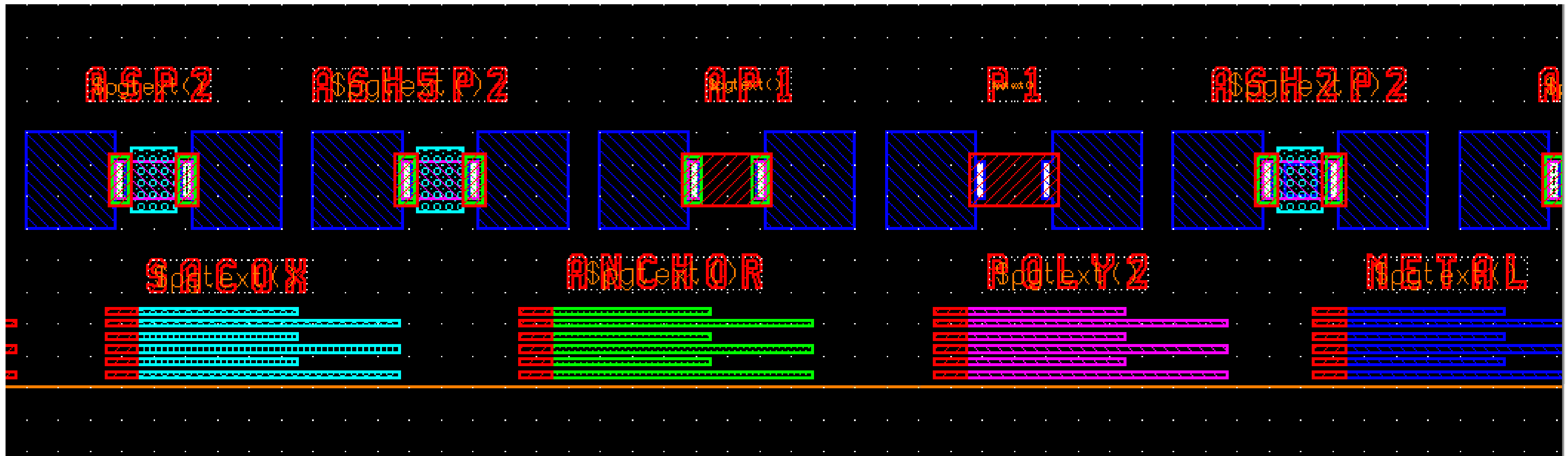
TEST STRUCTURES





One of the cells will have test structures along the bottom edge for resolution/overlay, etc.

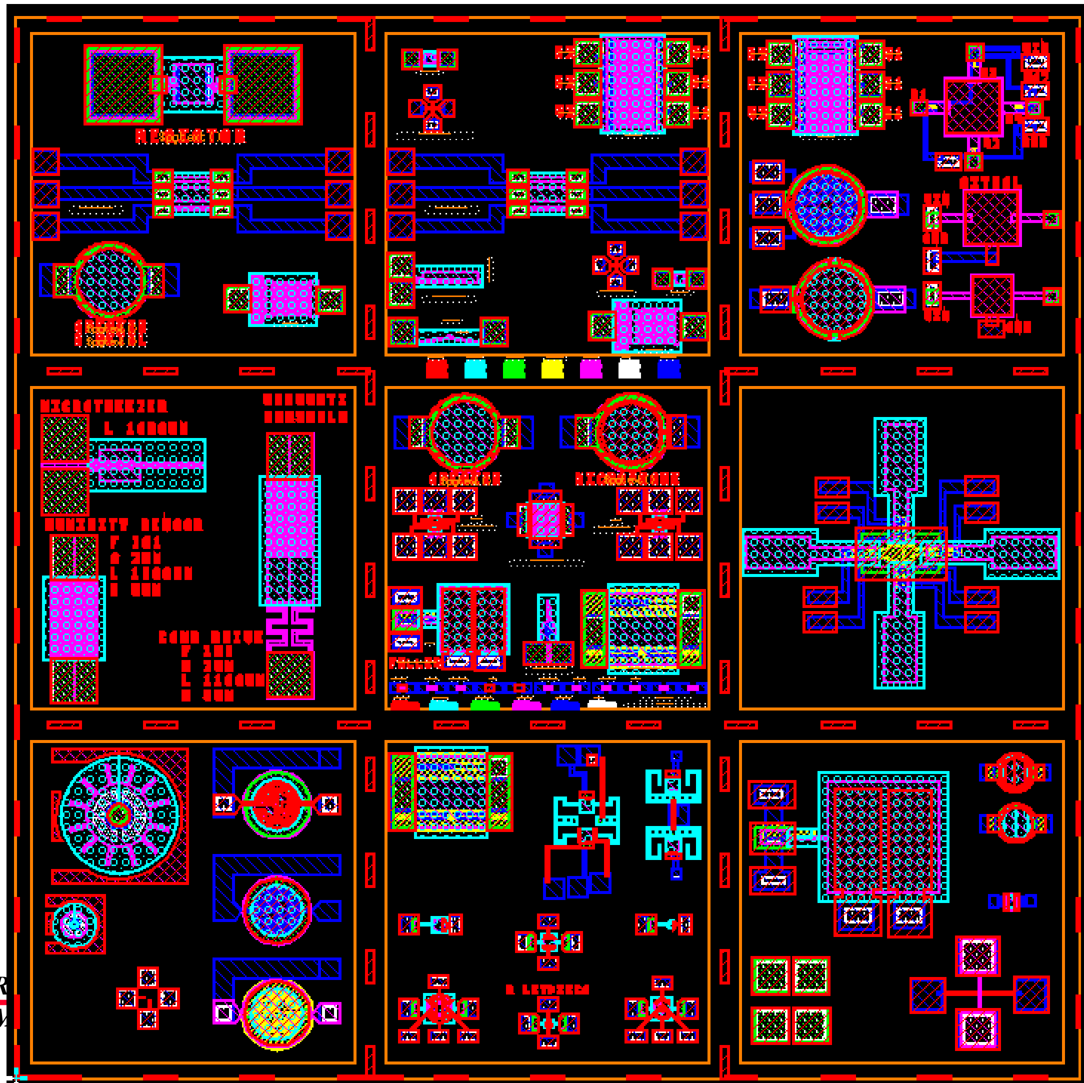
TEST STRUCTURES



1. Poly1 in Parallel with Poly2
2. No Etch Holes Poly 2
3. 5um Etch Holes Poly2
4. Metal contact to Poly2 to Poly1
5. Metal contact to Poly1
6. 2um Etch Holes Poly2
7. Poly2 No Implant, No SacOx
8. Poly2 No Implant
9. Poly2 No Implant 5um Gap
10. Poly2 No Implant 5um Resistor
11. Poly 2 No Implant 10um Resistor

Starting from Left Resistors
L = ~100µm W = ~50µm

2014 MEMS MULTICHIP PROJECT DESIGN



GDS II LAYER NUMBERS

The design layer names and colors are lost when converting to GDS II. Only the layer number is kept.

Individual Student Designs are converted to GDS-II files and emailed to course instructor.

Layer Palette

mems-2014 | User Order | Draw Order

Out SVF

Layer	Layer Number	Prev	S	V	F
poly1	1		✓	✓	✓
SacOx	2		✓	✓	✓
Anchor	3		✓	✓	✓
Poly2	4		✓	✓	✓
Metal	7		✓	✓	✓
Out	9		✓	✓	✓
Cut	6		✓	✓	✓
No_Implant	15		✓	✓	✓
Holes	16		✓	✓	✓

MASK ORDER FORM

Rochester Institute of Technology
Semiconductor & Microsystems Fabrication Laboratory

Maskmaking
Order Request

Name	Dr Fuller
Company	RIT
Department	
Street Address	
City, State and Zip Code	,
Phone Number	( ) -
SMFL Project Code	
Email Address	
Order Date	
Order Due Date	

Design File Name (.gds)	mems-2014-final.gds
Number of Mask Levels to be Written	7
Cell Layout Size	16.5mm x 16.5mm
Name of Cell in Design File to be used	mems-2014-final

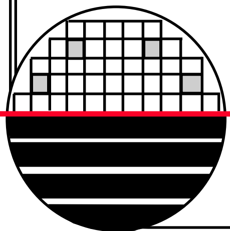
Mask Type Needed			
☐ Contact Aligner	Defaults	Scale:	1X
• Max field size – 105mm x 105mm		Mask Size:	5" x 5" x 0.09" Soda Lime
		Orientation:	Mirror 90
		Fracture Resolution:	0.5um
☐ GCA Stepper	Defaults	Scale:	5X
• Max field size – 20mm x 20mm		Mask Size:	5" x 5" x 0.09" Soda Lime
		Orientation:	Mirror 135
		Fracture Resolution:	0.5um
X ASML Stepper	Defaults	Scale:	5X
Max field size – 22mm x 22mm		Mask Size:	6" x 6" x 0.12" Quartz
		Orientation:	Mirror 90
		Fracture Resolution:	0.5um

Single Field Array Plate	☐ Yes
	☐ Array with columns (x) and rows (y)
Array element size	X: um Y: um

Notes:
If multiple design files are to be incorporated into your array – please specify the array layout separately
Your designs will be butted together to from the array unless otherwise specified

Multiple Field Array Plate	☐ Yes
Numbers of Levels on Plate	

Please specify which levels are to be grouped together on which plate on the Details Sheet



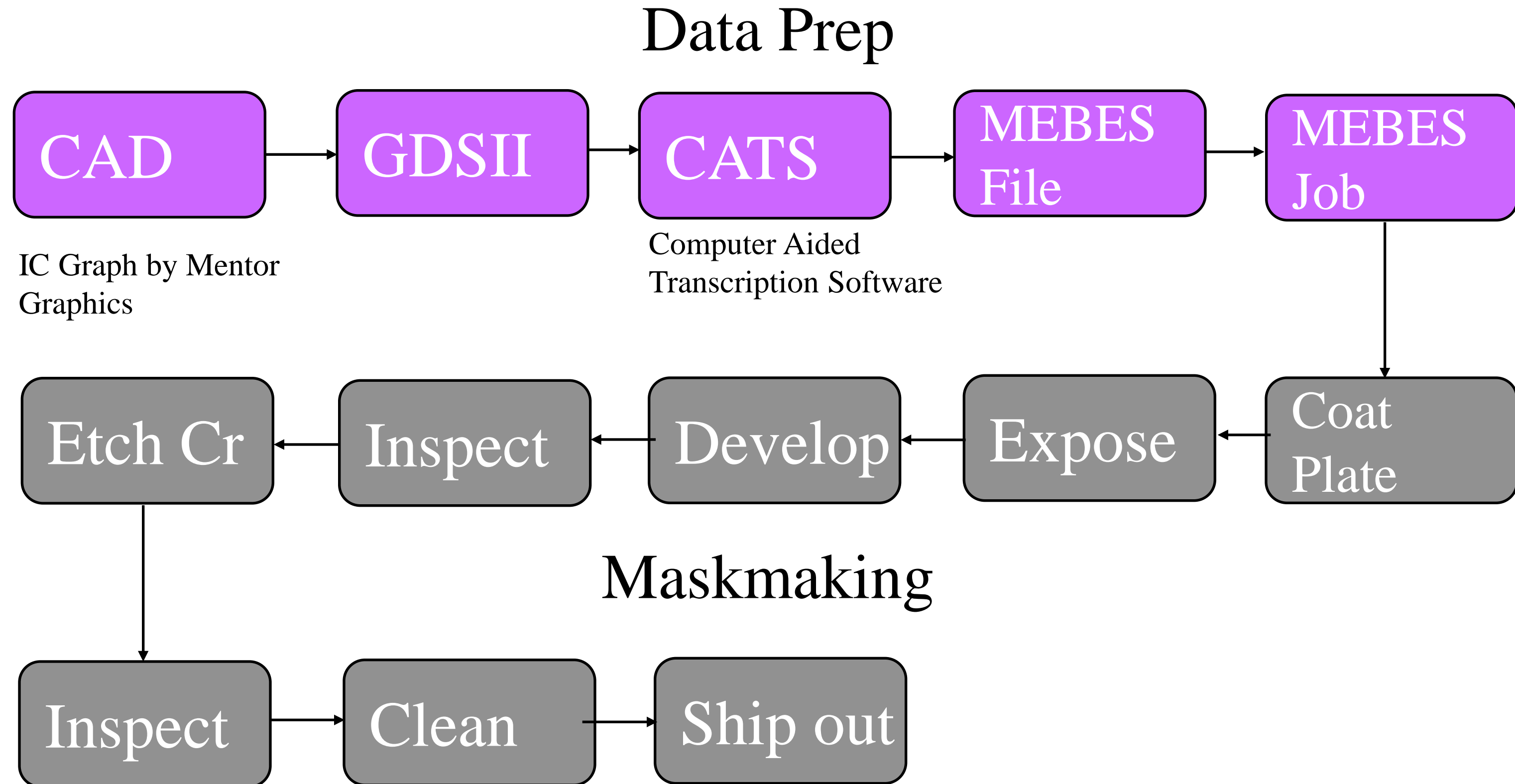
MASK ORDER FORM DETAILS

Reticle Number	Reticle Name	Design Layer #'s	Boolean Function	Dark/ Clear	Comment
1	Poly1	1	None	Clear	
2	SacOx	2	None	Clear	
3	Anchor	3	3 Inverted	Dark	
4	No Implant	15	None	Clear	
5	Poly2	4,16	4 AND (16 Inverted)	Clear	
6	Cut	6	6 Inverted	Dark	
7	Metal	7	None	Clear	

Design Layer 9 Out (outline) is not used. It is only for placement of projects on the multi-project reticle template.

cp <filename>.gds /dropbox/masks

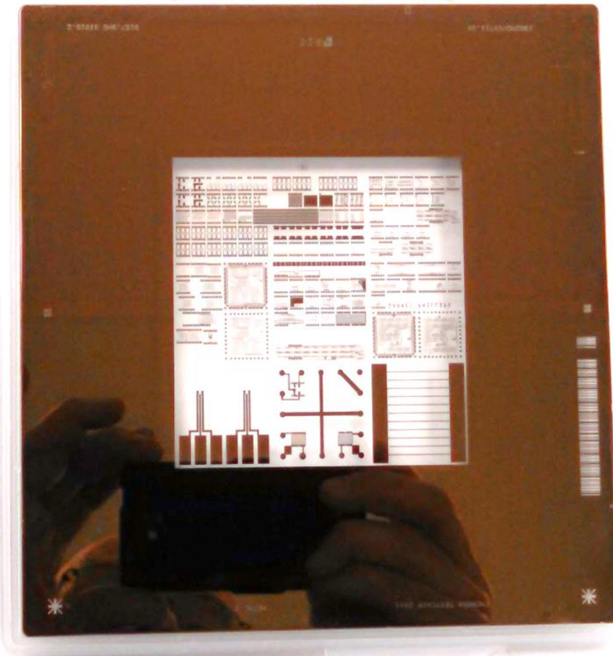
MASK PROCESS FLOW



This process can take weeks and cost between $1000 and $20,000 for each mask depending on the design complexity.

MEBES - Manufacturing Electron Beam Exposure System

ASML RETICLE



Chrome Side
Mirrored 90°
Chip Bottom at Bottom

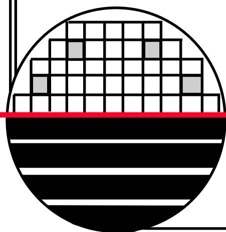
Non Chrome Side
As loaded into Reticle Pod, Chrome Down, Reticle Pre-Alignment Stars Sticking out of Pod

POSSIBLE NEW PROCESSES (NEED VERIFICATION)

Can we make isolated poly resistors by ion implant?
Sacrificial Oxide Etch Holes, Size, Spacing,

Sacrificial Oxide Etch Stop (poly) and Oxidation
Mechanical Poly Layer Deposition
Mechanical Poly Layer Etch Recipe (STS Tool)
Thick Resist Coat, Develop, Expose Recipes
- Use Stepper Job SMFL-ETM and Photomask
  - ETM Senior Test
  - 1827 Resist, 2500 rpm, 110°C
  - 4.1µm Thickness
  - 400mj/cm2 Focus +2µm
  - Develop same as DEVCC no hard bake

Metal Lift-Off
Sawing Recipes….
Release Sequence, Details,

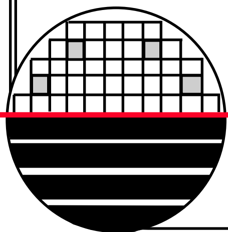


SURFACE MEMS 2014 PROCESS

1. Starting wafer
2. PH03 – level 0, Marks
3. ET29 – Zero Etch
4. ID01-Scribe Wafer ID, D1…
5. ET07 – Resist Strip, Recipe FF
6. CL01 – RCA clean
7. OX04 – 6500Å Oxide Tube 4
8. CV01 – LPCVD Poly 5000Å
9. PH03 – level 1 Poly-1
10. ET08 – Poly Etch
11. ET07 – Resist Strip, Recipe FF
12. CL01- RCA clean 2 HF dips
13. CV01- LPCVD Poly 1000Å
14. IM01-P31 2E16 100KeV
15. ~~OX04- Anneal Recipe 119~~
16. CV03-TEOS SacOx Dep 1.5um
17. PH03-level 2 SacOx
18. ET06-wet etch SacOx
19. ET07- Resist Strip, Recipe FF
20. CV03-TEOS Etch Stop
21. PH03-Level 3 Anchor-Thick Resist
22. ET06-Wet Etch Oxide
23. ET07-Resist Strip Recipe FF
24. CV01-LPCVD Poly 1.5um
25. PH03-Level 4 No Implant
26. IM01-P31 2E16 100KeV
27; ET07 Resist Strip, Recipe FFF
28. OX04-Anneal Recipe 119
29. DE01 Four Point Probe
30. PH03-Level 5 Poly2
31. ET68-STS Etch
32. ET07 Resist Strip, Recipe FFF
33. ET66-SacOx Etch
34. OX05-Consume Etch Stop Poly
35. PH03-Level 6 CC
36. ET06- wet etch BOE
37. ET07 Resist Strip, Recipe FFF
38. CL01-Special
39. ME01 – Sputter Aluminum
40. PH03-Level 7, Metal
41. ET15 – plasma Al Etch
42. ET07 – Resist Strip, Recipe FFF
43. SI01 – sinter Tube 2, Recipe ???
44. SEM1 – SEM Pictures
45. TE01 - Testing

STARTING WAFER – SCRIBE ID01

Starting Wafer



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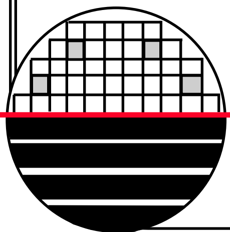
SSI COAT AND DEVELOP TRACK FOR 6" WAFERS

Use Recipe: MEMSCOAT.rcp and MEMSDEV.rcp

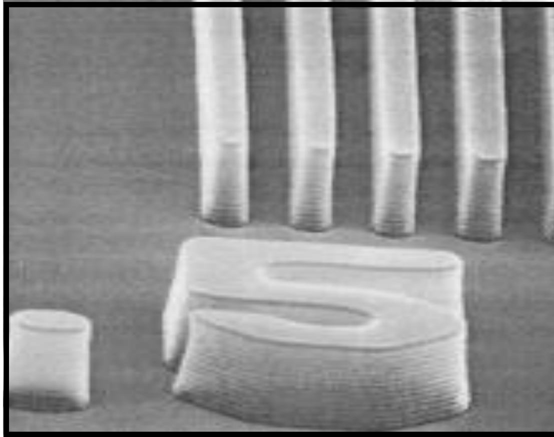


RECIPES FOR RESIST COAT AND DEVELOP

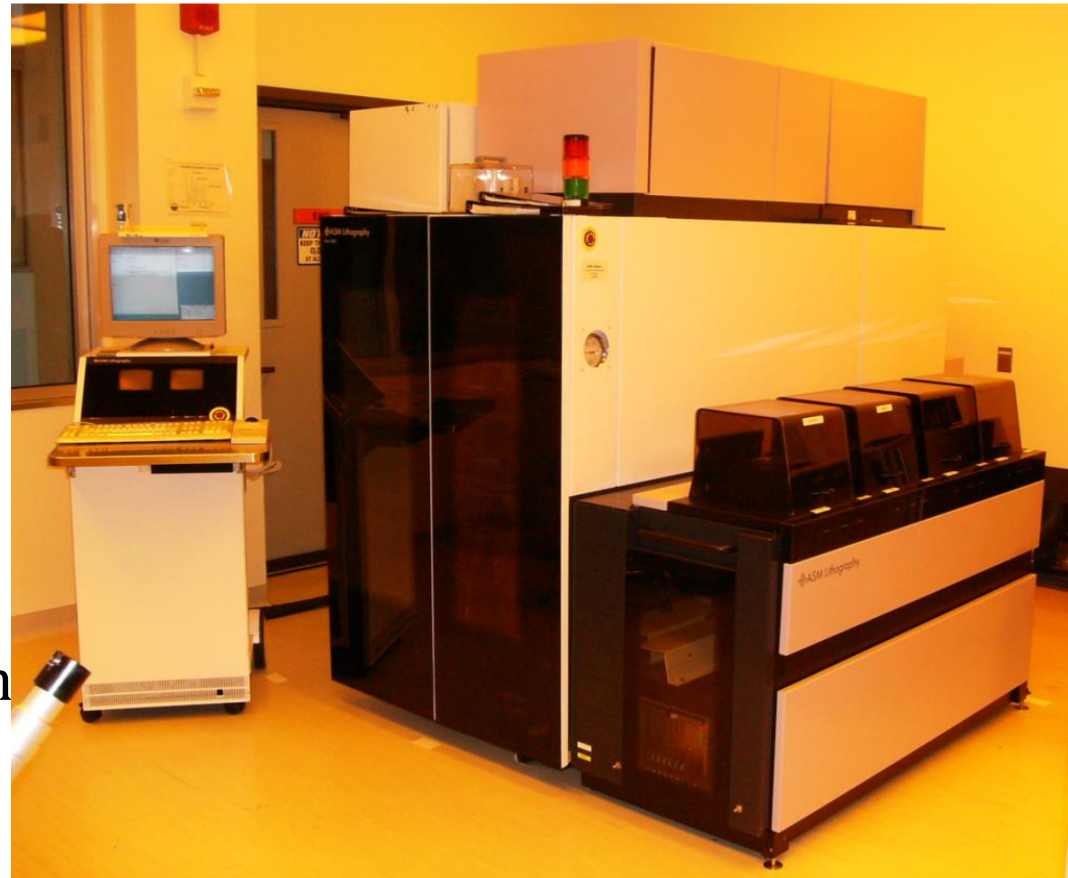
Level	Level Name	Resist	Coat Recipe	Develop Recipe	Resist Thickness
0	Zero	OIR-620	Coat	Develop	1.0um
1	Poly 1	OIR-620	Coat	Develop	1.0um
2	Sac Ox	OIR-620	Coat	Develop	1.0um
3	Anchor	S1827	MEMS-COAT	MEMS-DEV	4.5um
4	Poly 2	S1827	MEMS-COAT	MEMS-DEV	4.5um
5	CC	S1827	MEMS-COAT	MEMS-DEV	4.5um
6	Metal 1	S1827	MEMS-COAT	MEMS-DEV	4.5um

MEMSCOAT.rcp 2500rpm, 30sec, Hand Dispense, 110°C, 1min
Exposure for S1827, 400mj/cm2, Focus +2.0, NA=0.46, σ=0.45
MEMSDEV.rcp has 200 second develop time, no hardbake

ASML 5500/200



NA = 0.48 to 0.60 variable
σ= 0.35 to 0.85 variable
With Variable Kohler, or Variable Annular illumination
Resolution = K1 λ/NA
= ~ 0.35µm
for NA=0.6, σ =0.85
Depth of Focus = k_2 $\lambda/(NA)^2$
= 1.0 µm for NA = 0.6

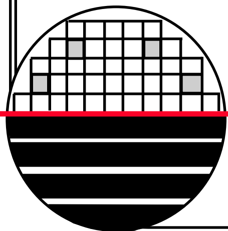


i-Line Stepper λ = 365 nm
22 x 27 mm Field Size

STEPPER JOB

Mask Barcode:

Stepper Jobname: MCEE770-MEMS
- Level 0 (combi reticle)
- Level Clearout (combi reticle)
- Level SacOx
- Level Poly 1
- Level Anchor
- Level Poly 2
- Level CC
- Level Metal
- Level No Implant
- Level MEMS-Test (no alignment)



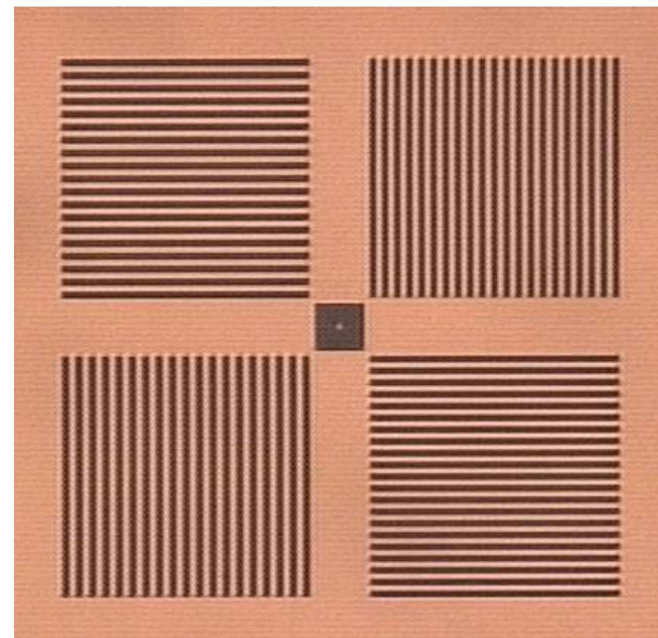
DRYTEK QUAD RIE TOOL

ZERO ETCH FOR ASML ALIGNMENT MARKS

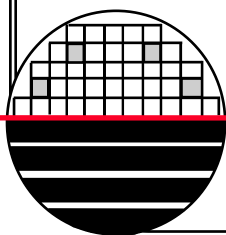
Recipe Name:	ZEROETCH	
Chamber		3
Power		200W
Pressure		100 mTorr
Gas 1	CHF_3	50 sccm
Gas 2	CF_4	25 sccm
Gas 3	Ar	0 sccm
Gas 4	O_2	10 sccm

Max Time = 120 seconds

Silicon Etch Rate 650 Å/min



8.8 um L/S 8 um L/S



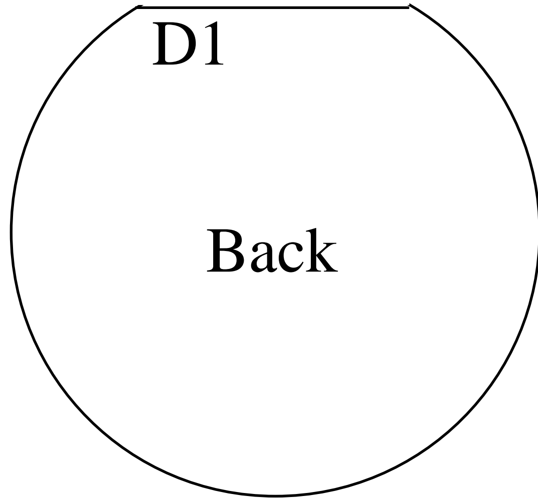
ASHER, SCRIBE, RCA CLEAN & SRD

O_2 + Energy = 2 O
O is reactive and will combine with plastics, wood, carbon, photoresist, etc.

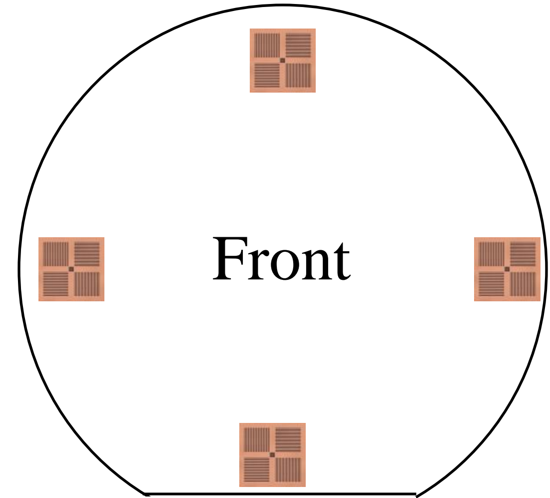
Gassonics Asher
Recipe FFF

RCA Clean Bench

SCRIBE WAFER WITH ID NUMBER



Scribe on back of wafer
near the wafer flat
ID numbers D1, D2…etc.



Wafer has alignment marks etched in four locations

RCA CLEAN

APM

NH_4OH - 1part
H_2O_2 - 1parts
H_2O - 17parts
70 °C, 15 min.

→ DI water rinse, 5 min.

→ H_20 - 50
HF - 1
30 sec.

→ DI water rinse, 5 min.

→ HPM

HCL - 1part
H_2O_2 - 1parts
H_2O - 17parts
70 °C, 15 min.

→ DI water rinse, 5 min.

→ SPIN/RINSE DRY

USING EXCEL SPREADSHEET FOR OXIDE GROWTH CALCULATIONS

	A	B	C	D	E	F	G	H	I	J
1	ROCHESTER INSTITUTE OF TECHNOLOGY							OXIDE.XLS		
2	MICROELECTRONIC ENGINEERING							7/4/2014		
3										
4	CALCULATION OF OXIDE THICKNESS					Dr. Lynn Fuller / Jamie Wasiewicz				
5										
6	To use this spreadsheed change the values in the white boxes. The rest of the sheet is									
7	protected and should not be changed unless you are sure of the consequences. The									
8	calculated results are shown in the purple boxes. O2 bubbled through warm water is "wet",									
9	burning H2 with O2 is called "steam"									
10										
11	CONSTANTS			VARIABLES				CHOICES		
12	K	1.38E-23	J/K					1=yes, 0=no		
13	(Bo/Ao) dry	6230000	µm/hr		Temp =	1100	°C	wet	0	
14	Ea (dry)	2	eV		time =	65	min	dry	0	
15	(Bo/Ao) wet	89500000	µm/hr		Partial Pressure, p =	1.00	Atm	steam	1	
16	Ea (wet)	2.05	eV					<100>	1	
17	(Bo/Ao) steam	1.63E+08	µm/hr					<111>	0	
18	Ea (steam)	2.05	eV							
19	Bo dry	7.72E+02	µm2/hr		Xint=	0	Å			
20	Ea (dry)	1.23	eV							
21	Bo wet	2.14E+02	µm2/hr	Silicon VLSI Technology, Plummer, Deal, Griffin						
22	Ea (wet)	0.71	eV			Prentice Hall, 2000, pg 319-369				
23	Bo steam	3.86E+02	µm2/hr							
24	Ea (steam)	0.78	eV	(Bo/Ao)/1.68 for <100>						
25										
26	CALCULATIONS:									
27										
28		Xox (Oxide thickness)=(A/2){[1+(t+Tau)4B/A^2]^0.5 -1} =						6765 Å		
29										
30		B = [Bo exp (-Ea/KTemp)]*p				0.5338344	µm2/hr			
31		B/A = [(Bo/Ao) exp (-Ea/KTemp)]*p				2.99E+00	µm/hr			
32		A				0.1784766	µm			
33		Tau = (Xi2+AXi)/B				0	hr			

Xox

Oxide SiO2

Silicon

Origional Silicon Surface Prior to Oxide Growth

0.46 Xox (silicon consumed)

These spreadsheets are available on Dr. Fullers webpage.

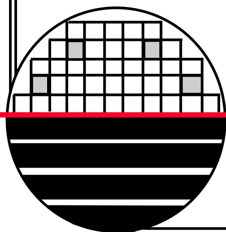
BRUCE FURNACE RECIPE 406 – WET OXIDE 6,500Å

Recipe #406

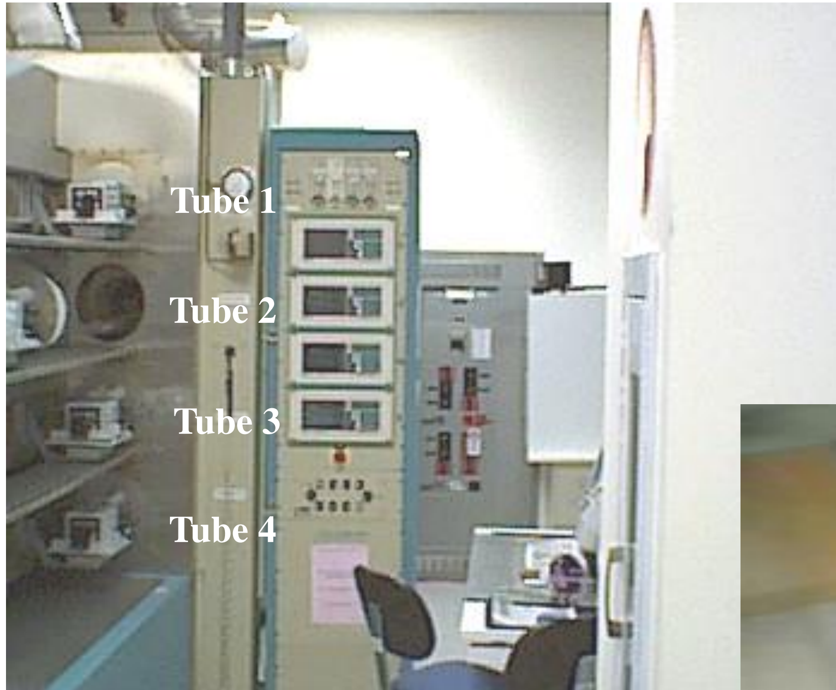
	Interval 0	Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7	Interval 8
Step	Boat Out Load	Boat In Push	Stabilize	Ramp-Up	Soak		Anneal	Ramp-Down	Boat Out Pull
Temperature	25 °C	800 °C	800 °C		1100°C				800 °C
Time	Any	12 min	15 min	30 min	5 min	65 min	5 min	60 min	12 min
Flow	0 lpm	10 lpm	10 lpm	5 lpm	5 lpm	3.6/2 lpm	15 lpm	10 lpm	15 lpm
Gas	none	N2	N2	N2	O2	O2/H2	N2	N2	N2

At the end of a run the furnace returns to Interval 0 which is set for boat out, 25 °C and no gas flow. The furnace waits in that state until someone aborts the current recipe or loads a new recipe.

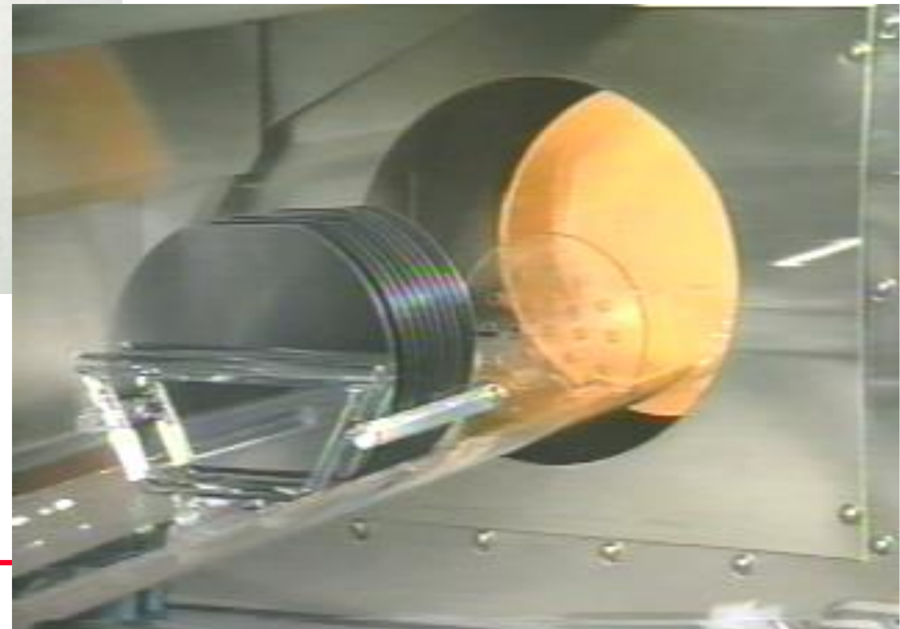
Wet Oxide Growth, Target 6,500 Å



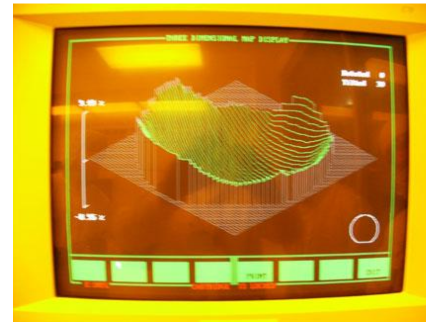
BRUCE FURNACE

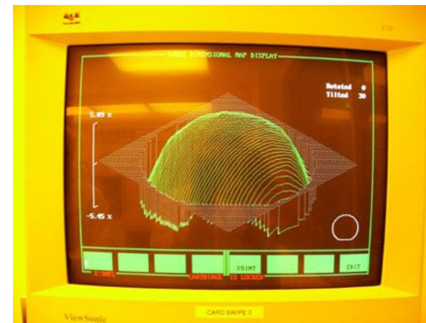


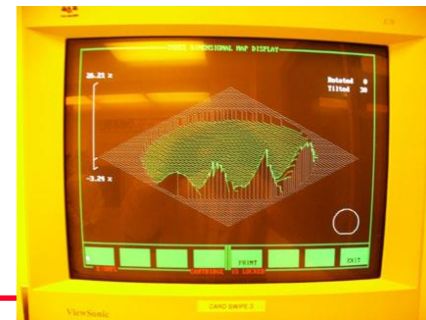
Tube 1 Steam Oxides
Tube 2 P-type Diffusion
Tube 3 N-type Diffusion
Tube 4 Dry Oxides and
Gate Oxides



TENCORE FT-300 SPECROMAP



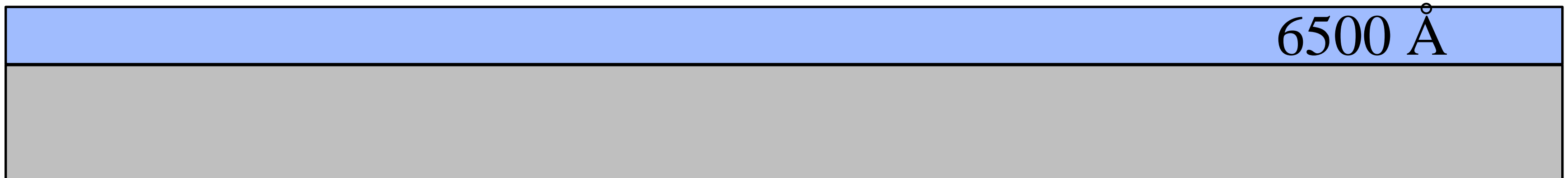




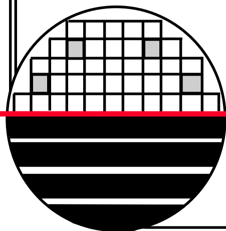
Record:

Mean
Std Deviation
Min
Max
No of Points

AFTER 6500Å OXIDE GROWTH



Starting Wafer



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DEPOSIT POLYSILICON

Poly Target 5000A
LPCVD, 610C, Rate ~64Å/min
Time~78 min

Recipe POLY 610
Temp = 610°C
Pressure = 300 mTorr
Silane Flow = 90 sccm

Substrate

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SSI COAT AND DEVELOP TRACK FOR 6" WAFERS

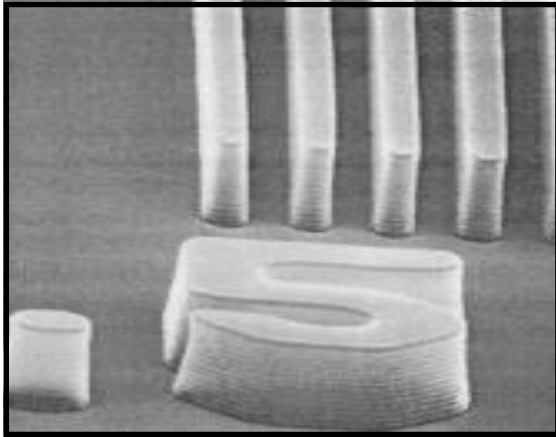
Use Recipe: Coat.rcp and Develop.rcp

RECIPES FOR RESIST COAT AND DEVELOP

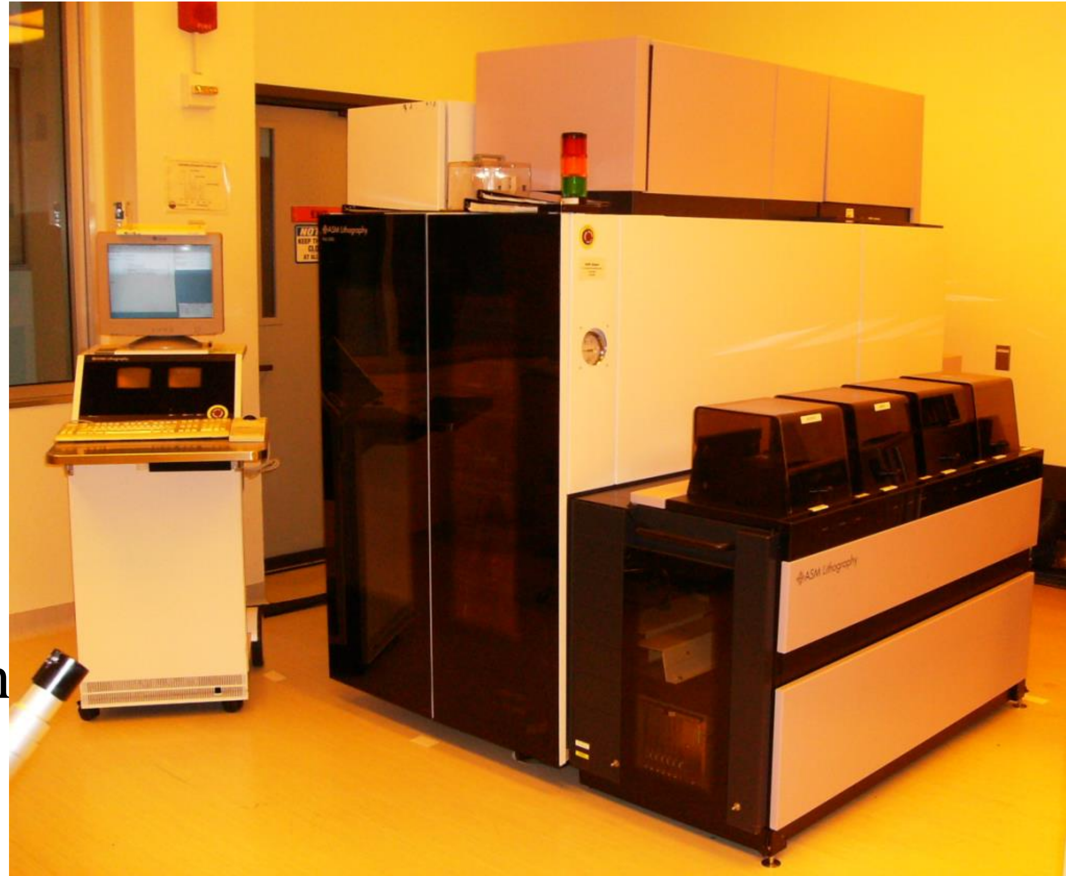
Level	Level Name	Resist	Coat Recipe	Develop Recipe	Resist Thickness
0	Zero	OIR-620	Coat	Develop	1.0um
1	Poly 1	OIR-620	Coat	Develop	1.0um
2	Sac Ox	OIR-620	Coat	Develop	1.0um
3	Anchor	S1827	MEMS-COAT	MEMS-DEV	4.5um
4	Poly 2	S1827	MEMS-COAT	MEMS-DEV	4.5um
5	CC	S1827	MEMS-COAT	MEMS-DEV	4.5um
6	Metal 1	S1827	MEMS-COAT	MEMS-DEV	4.5um

MEMSCOAT.rcp 2500rpm, 30sec, Hand Dispense, 110°C, 1min
Exposure for S1827, 400mj/cm2, Focus +2.0, NA=0.46, σ=0.45
MEMSDEV.rcp has 200 second develop time, no hardbake

ASML 5500/200



NA = 0.48 to 0.60 variable
σ= 0.35 to 0.85 variable
With Variable Kohler, or Variable Annular illumination
Resolution = K1 λ/NA
= ~ 0.35μm
for NA=0.6, σ =0.85
Depth of Focus = k_2 $\lambda/(NA)^2$
= 1.0 μm for NA = 0.6

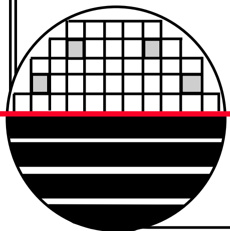


i-Line Stepper λ = 365 nm
22 x 27 mm Field Size

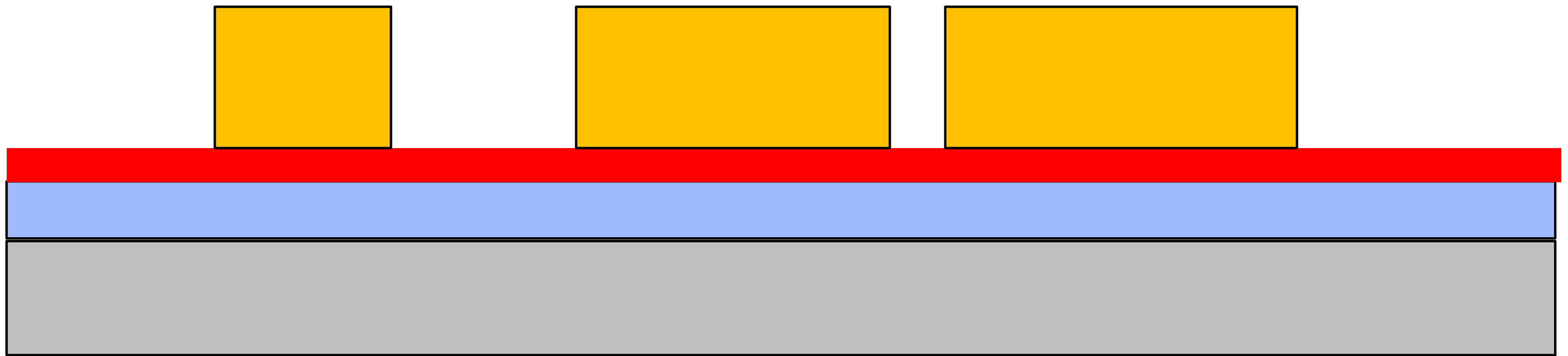
STEPPER JOB

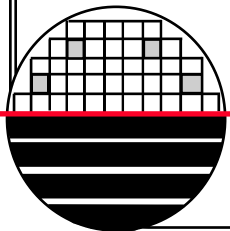
Mask Barcode:

Stepper Jobname: MCEE770-MEMS
- Level 0 (combi reticle)
- Level Clearout (combi reticle)
- Level SacOx
- Level Poly 1
- Level Anchor
- Level Poly 2
- Level CC
- Level Metal
- Level No Implant
- Level MEMS-Test (no alignment)



AFTER PHOTORESIST COAT, EXPOSE & DEVELOP





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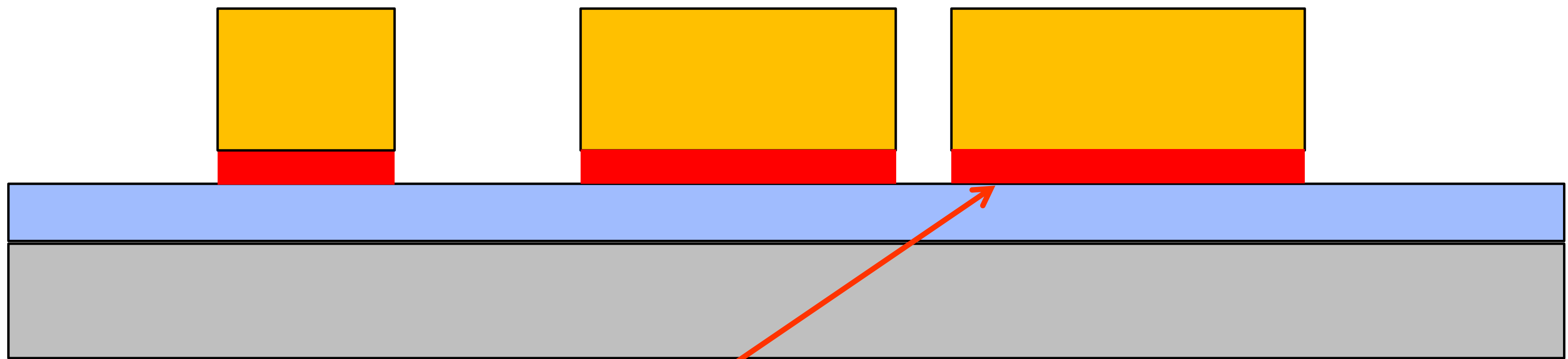
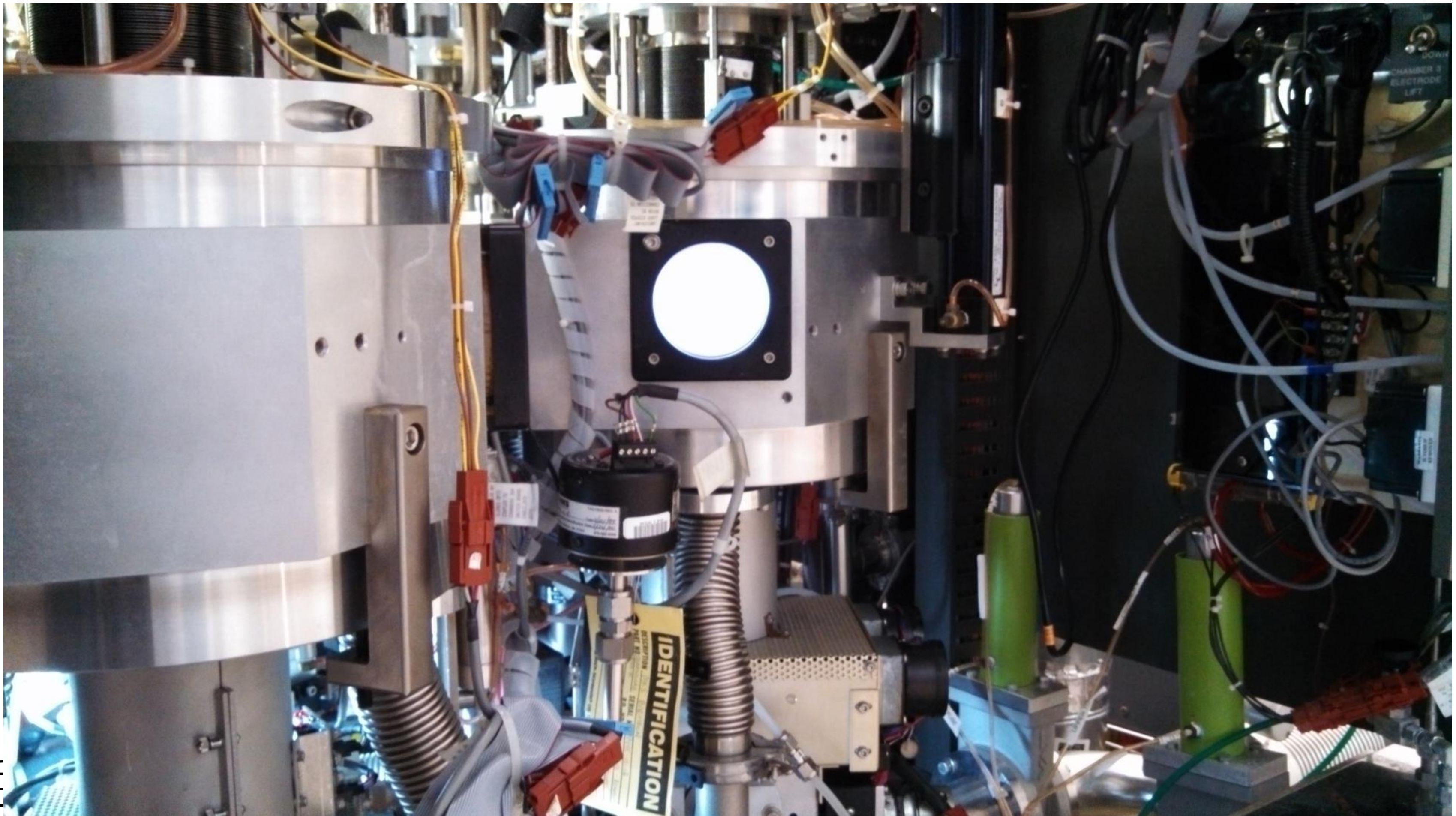
AFTER POLY1 ETCH



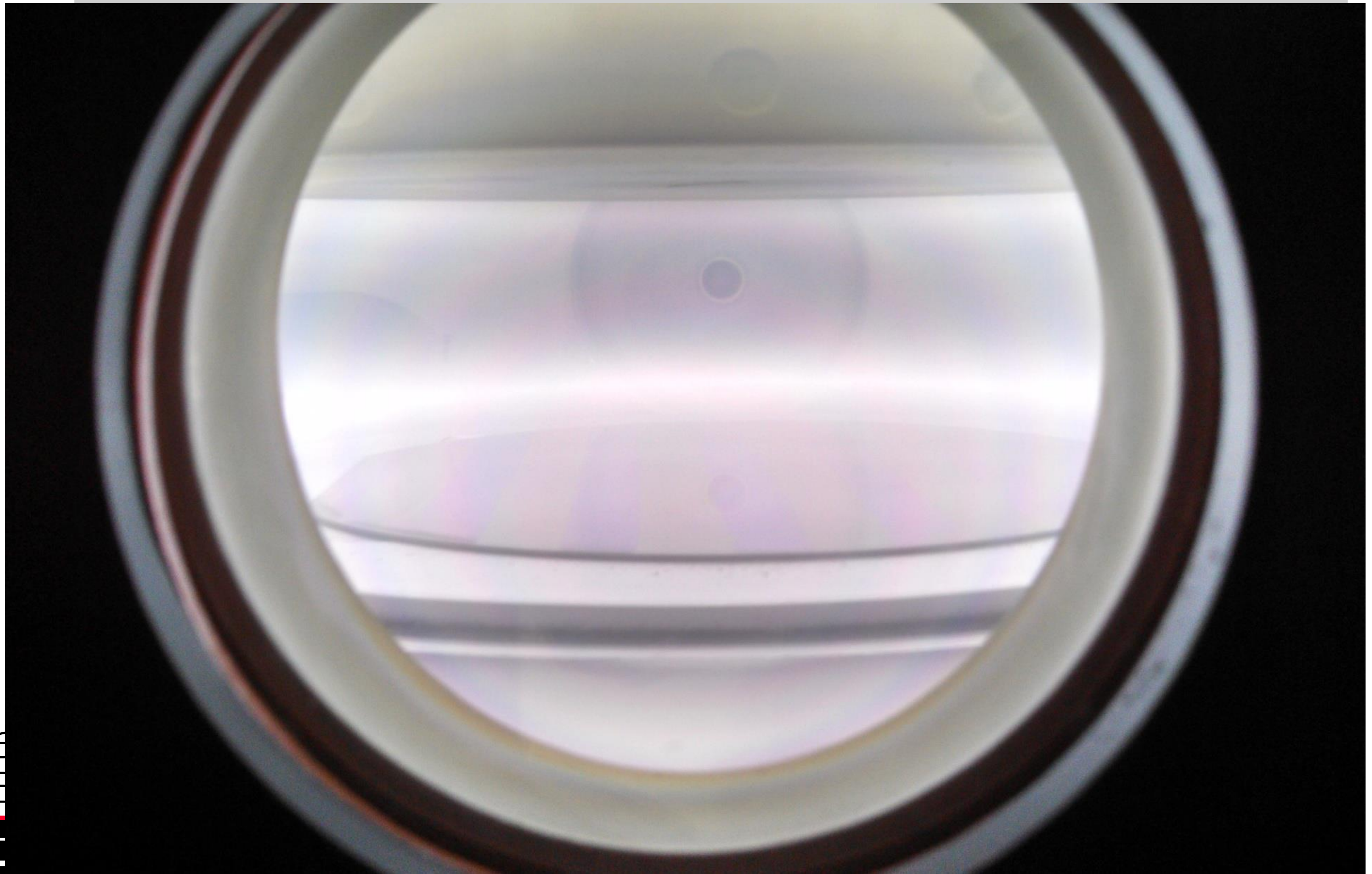
5000Å Poly

Drytek Quad
Recipe FACPOLY
Etch Rate ~1150Å/min

2 OF 4 CHAMBERS IN THE DRYTEK QUAD RIE TOOL



PLASMA ETCHING IN THE DRYTEK QUAD



ANISOTROPIC POLY GATE ETCH RECIPE

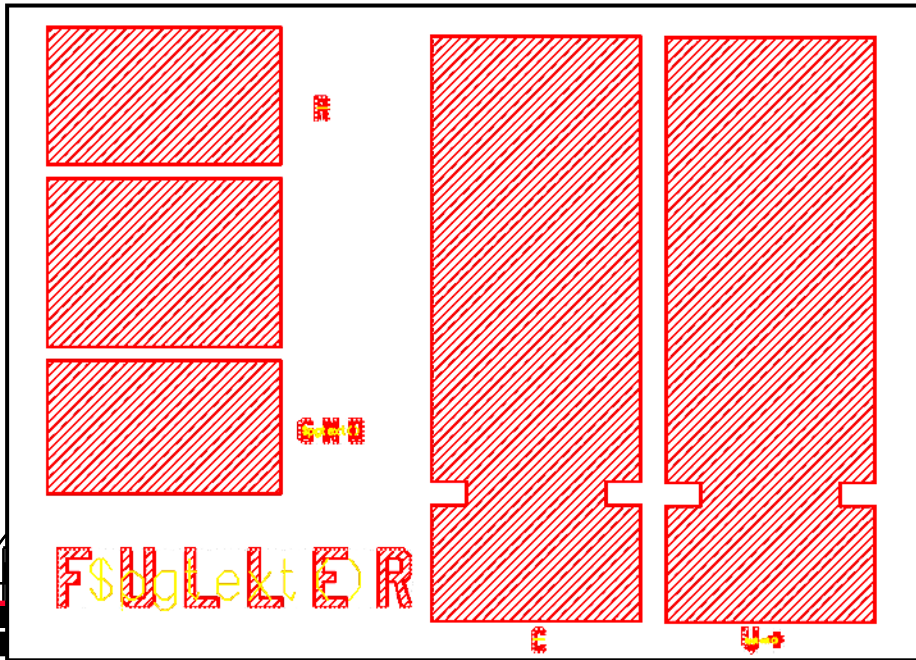
Anisotropic Poly Gate Etch Recipe

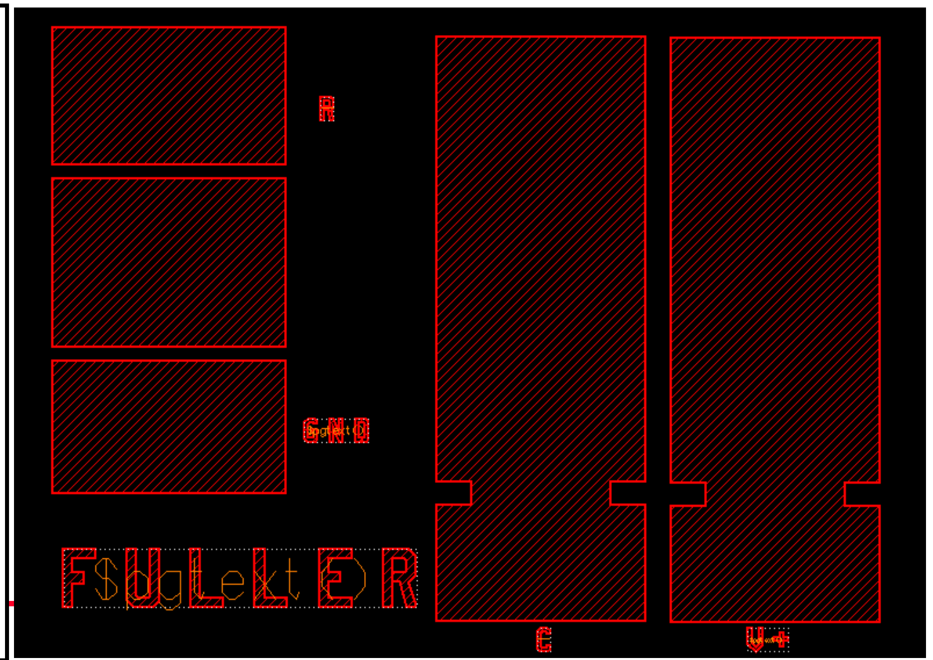
SF6 30 sccm, CHF3 30 sccm, O2 5 sccm, RF Power 160 w, Pressure 40 mTorr, 1900 A/min (Anisotropic), Resist Etch Rate 300 A/min, Oxide Etch Rate 200 A/min

Recipe Name:	FACPOLY Step 2
Chamber	2
Power	160 watts
Pressure	40 mTorr
Gas	SF6
Flow	30 sccm
Gas	CHF3
Flow	30 sccm
Gas	O2
Flow	5 sccm
Poly Etch Rate	1150 Å/min
Photoresist Etch Rate:	300 Å/min
Oxide Etch Rate:	200 Å/min

Endpoint See Video
http://people.rit.edu/lffeee/videos.htm

STRIP RESIST, RCA CLEAN





SPECIAL RCA CLEAN (TWO 50:1 HF STEPS)

PLAY

APM
NH_4OH - 1part
H_2O_2 - 3parts
H_2O - 15parts
70 °C, 15 min.

→ DI water rinse, 5 min.

→ H_20 - 50
HF - 1
60 sec.

→ DI water rinse, 5 min.

→ HPM
HCL - 1part
H_2O_2 - 3parts
H_2O - 15parts
70 °C, 15 min.

→ DI water rinse, 5 min.

→ H_20 - 50
HF - 1
60 sec.

→ DI water rinse, 5 min.

→ SPIN/RINSE DRY

Clean includes 50:1 HF Dip twice once after each bath to remove chemically grown oxide

DEPOSIT POLYSILICON

Poly Target 1000A
LPCVD, 610C, Rate ~67Å/min
Time~15 min

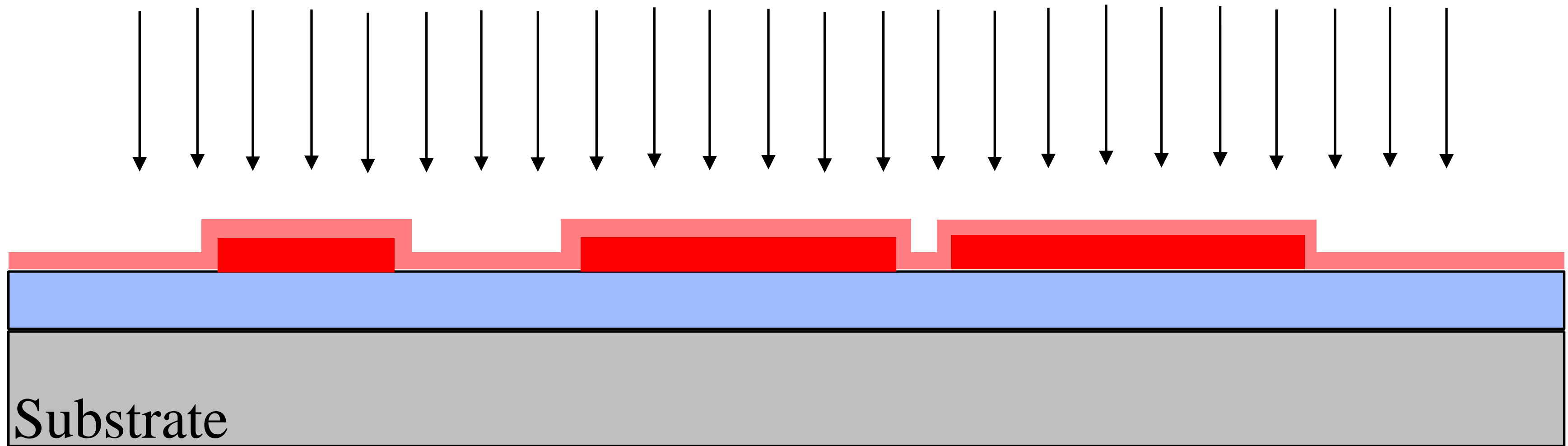
Recipe POLY 610
Temp = 610°C
Pressure = 300 mTorr
Silane Flow = 90 sccm

Substrate

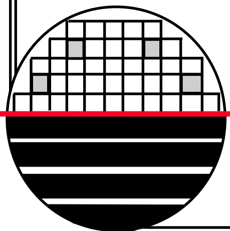
Rochester Institute of Technology
Microelectronic Engineering

VARIAN 350 D ION IMPLANTER (4" AND 6" WAFERS)

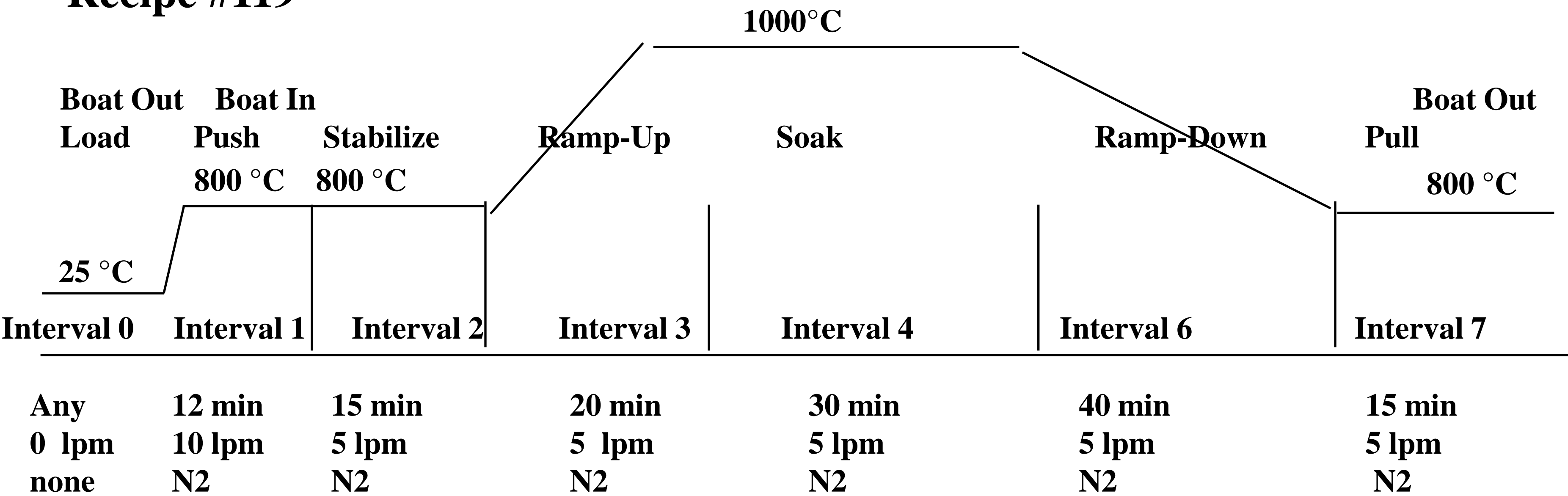
POLYSILICON DOPING



Ion Implant P31
Dose = 2E16 cm-2
Energy = 100KeV
Time ~?? min at 400 µA
Anneal Tube 2 Recipe 119



BRUCE RECIPE 119 – N++ POLY DOPE/ANNEAL

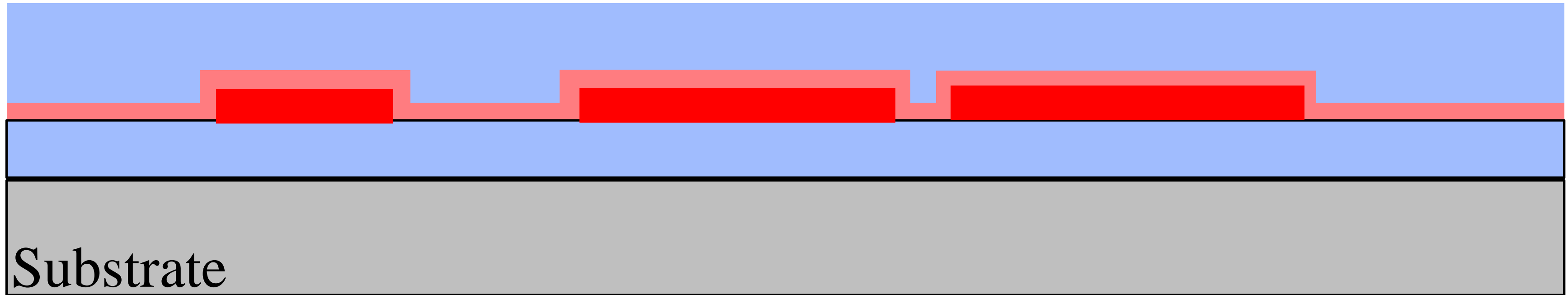


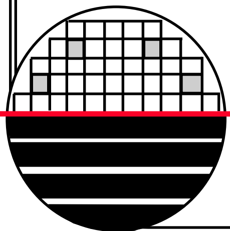
Interval 0	Interval 1	Interval 2	Interval 3	Interval 4	Interval 6	Interval 7
Any	12 min	15 min	20 min	30 min	40 min	15 min
0 lpm	10 lpm	5 lpm	5 lpm	5 lpm	5 lpm	5 lpm
none	N2	N2	N2	N2	N2	N2

At the end of a run the furnace returns to Interval 0 which is set for boat out, 25 °C and no gas flow. The furnace waits in that state until someone aborts the current recipe or loads a new recipe.

N+ Poly Doping/Anneal, Thick Poly, > 1 µm, No Oxide Growth

SAC OX DEPOSITION





PECVD OXIDE FROM TEOS

TEOS Program: (Chamber A)
Step 1
- Setup Time = 15 sec
- Pressure = 9 Torr
- Susceptor Temperature= 390 C
- Susceptor Spacing= 220 mils
- RF Power = 0 watts
- TEOS Flow = 400 scc
- O2 Flow = 285 scc

Step 2 – Deposition
- Dep Time = 55 sec (5000 Å)
- Pressure = 9 Torr
- Susceptor Temperature= 390 C
- Susceptor Spacing= 220 mils
- RF Power = 205 watts
- TEOS Flow = 400 scc
- O2 Flow = 285 scc

Step 3 – Clean
- Time = 10 sec
- Pressure = Fully Open
- Susceptor Temperature= 390 C
- Susceptor Spacing= 999 mils
- RF Power = 50 watts
- TEOS Flow = 0 scc
- O2 Flow = 285 scc

SSI COAT AND DEVELOP TRACK FOR 6" WAFERS

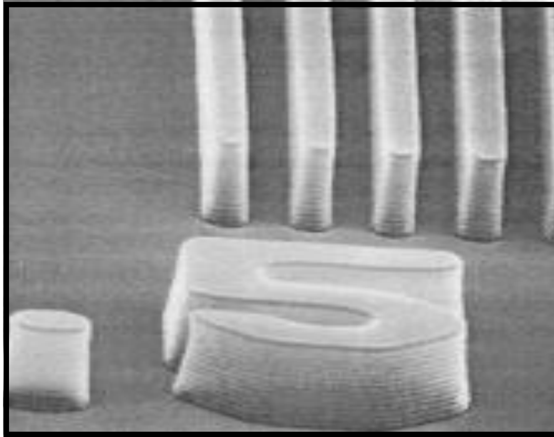
Use Recipe: Coat.rcp and Develop.rcp

RECIPES FOR RESIST COAT AND DEVELOP

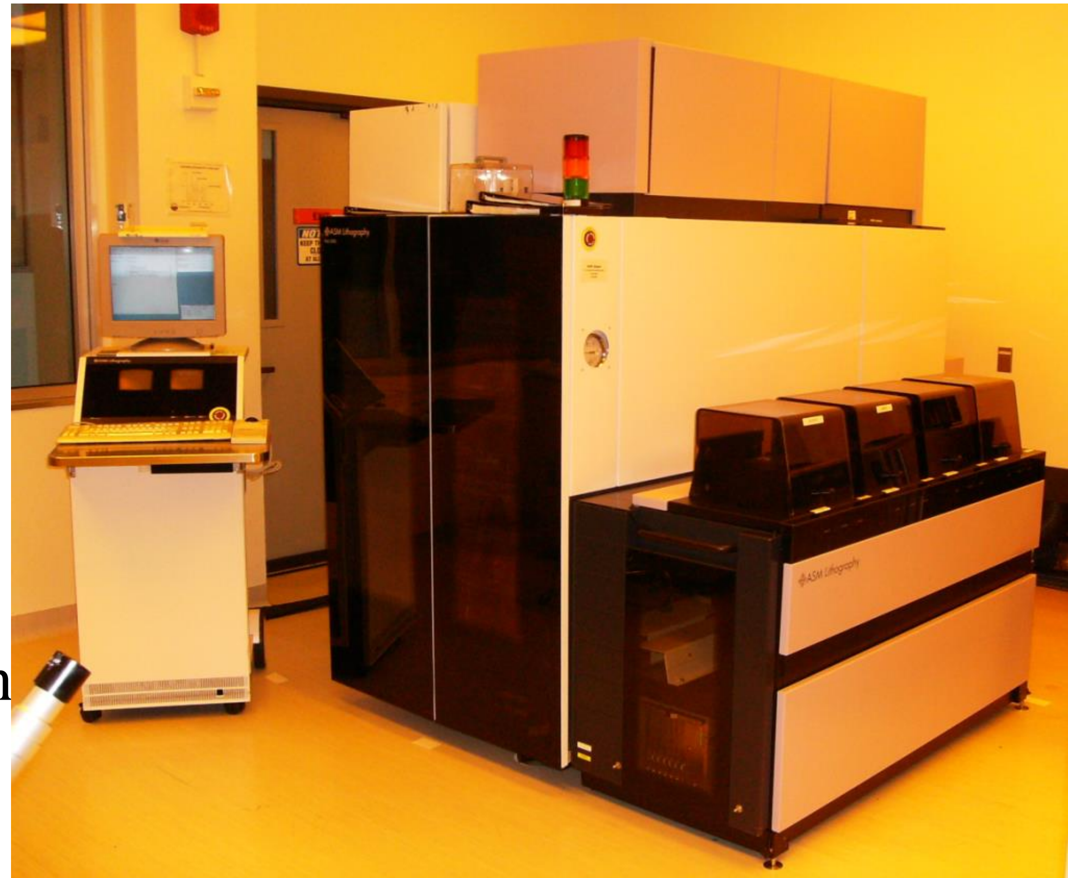
Level	Level Name	Resist	Coat Recipe	Develop Recipe	Resist Thicknes s
0	Zero	OIR-620	Coat	Develop	1.0um
1	Poly 1	OIR-620	Coat	Develop	1.0um
2	Sac Ox	OIR-620	Coat	Develop	1.0um
3	Anchor	S1827	MEMS-COAT	MEMS-DEV	4.5um
4	Poly 2	S1827	MEMS-COAT	MEMS-DEV	4.5um
5	CC	S1827	MEMS-COAT	MEMS-DEV	4.5um
6	Metal 1	S1827	MEMS-COAT	MEMS-DEV	4.5um

MEMSCOAT.rcp 2500rpm, 30sec, Hand Dispense, 110°C, 1min
Exposure for S1827, 400mj/cm2, Focus +2.0, NA=0.46, σ=0.45
MEMSDEV.rcp has 200 second develop time, no hardbake

ASML 5500/200



NA = 0.48 to 0.60 variable
σ= 0.35 to 0.85 variable
With Variable Kohler, or
Variable Annular illumination
Resolution = K1 λ/NA
= ~ 0.35µm
for NA=0.6, σ =0.85
Depth of Focus = $k_2\ \lambda/(NA)^2$
= 1.0 µm for NA = 0.6



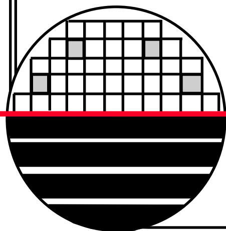
i-Line Stepper λ = 365 nm
22 x 27 mm Field Size

STEPPER JOB

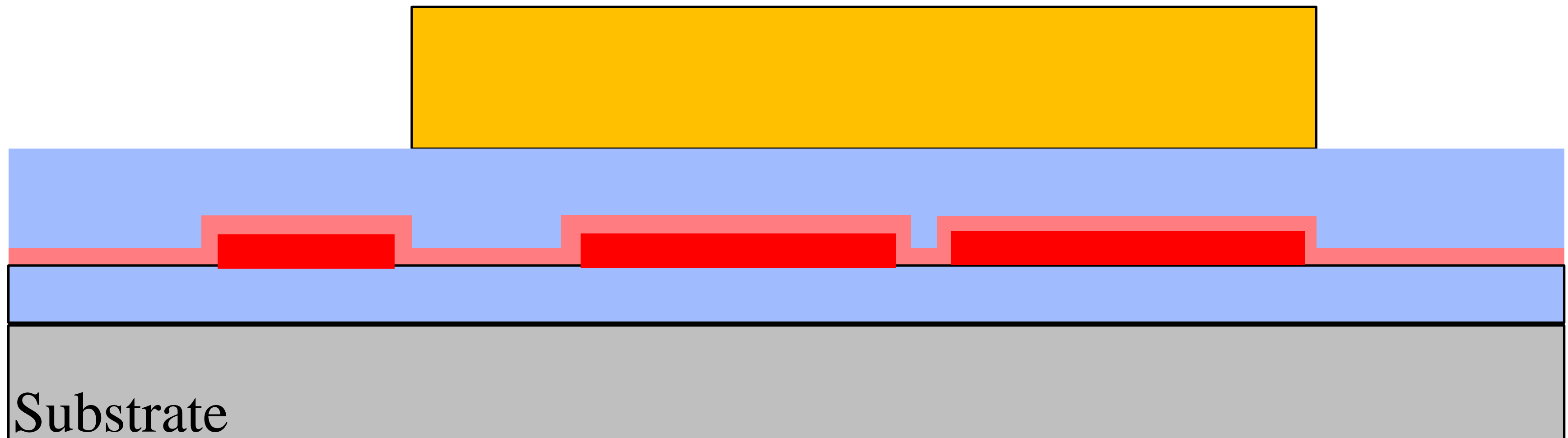
Mask Barcode:

Stepper Jobname: MCEE770-MEMS

- Level 0 (combi reticle)
- Level Clearout (combi reticle)
- Level SacOx
- Level Poly 1
- Level Anchor
- Level Poly 2
- Level CC
- Level Metal
- Level No Implant



AFTER SAC OX PHOTO AND ETCH



Etch SacOx

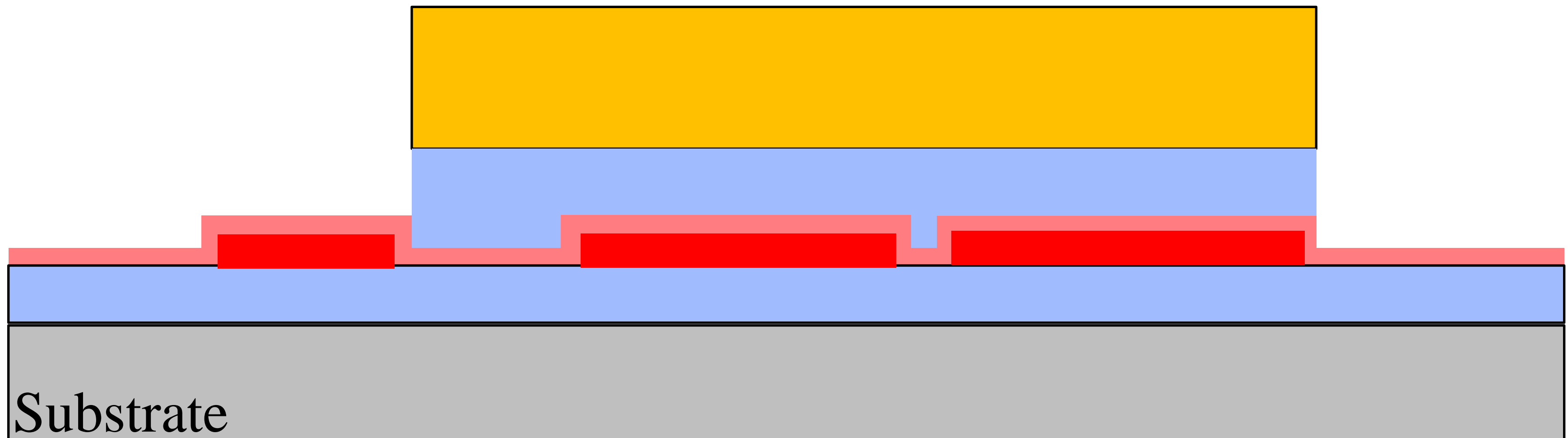
Etch Rate = 2633Å/min

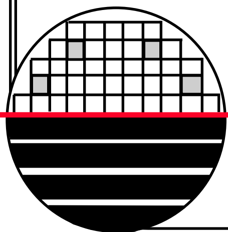
Using 5:1BOE

~6min. For 1.4um TEOS

Rinse 5 min. SRD

AFTER SAC OX PHOTO AND ETCH





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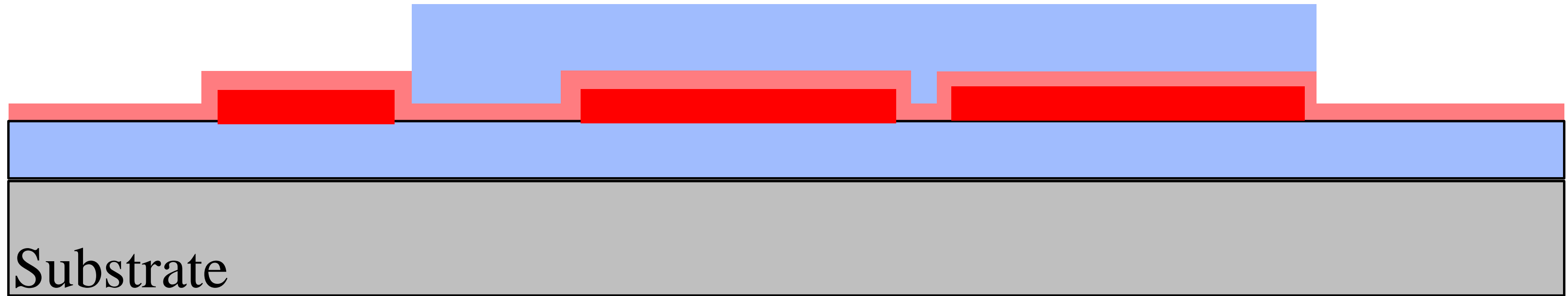
RESIST STRIP



R

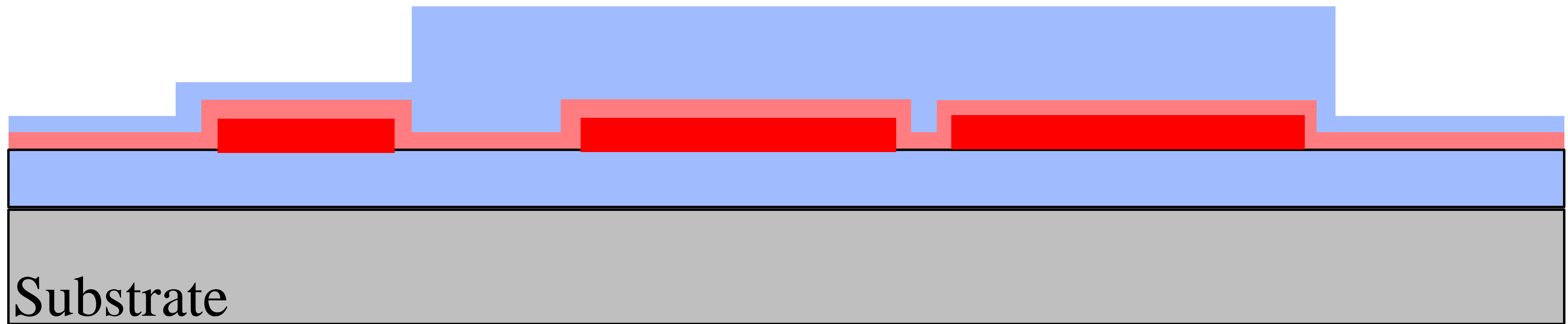
GND

FULLER

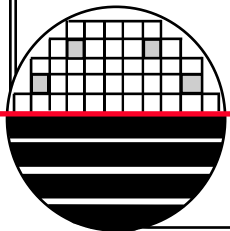
C

V+

DEPOSIT ETCH STOP



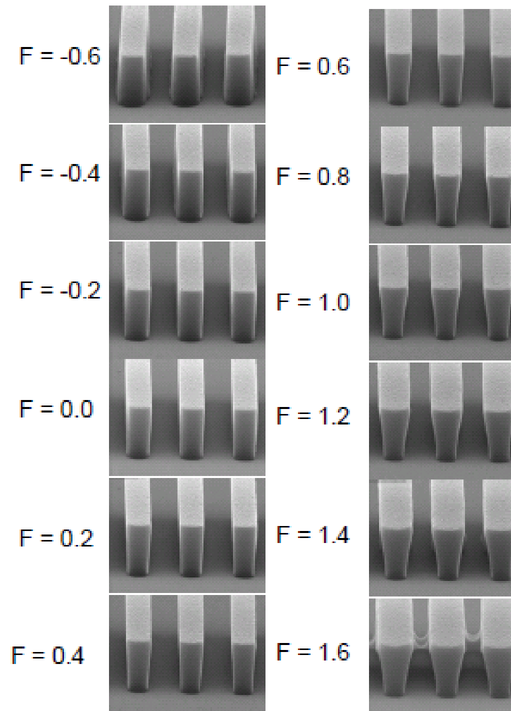
TEOS Oxide
2000Å

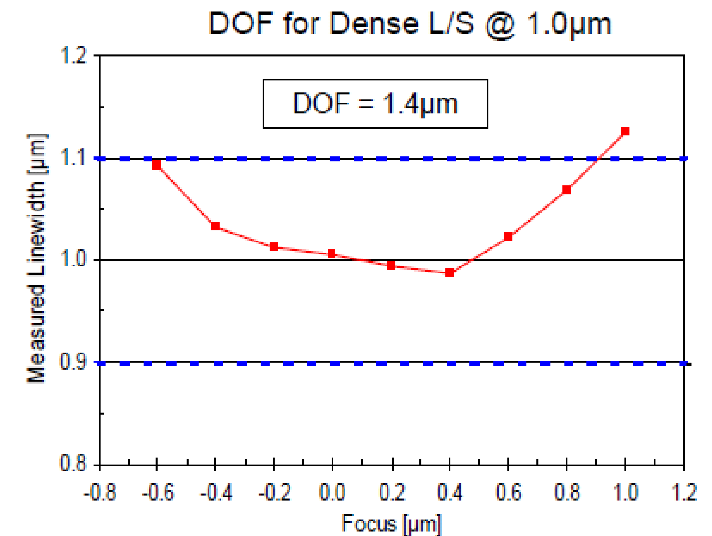


CLEAR FIELD MASKS

USING IMAGE REVERSAL RESIST

AZ nLOF 2020
Depth of Focus @ 1.0 µm CD





FT = 2.0µm, SB 110°C/ 60 sec, PEB 110°C/ 60 sec, 60 sec single puddle in AZ 300 MIF Developer @ 23°C Nikon 0.54 NA I-line

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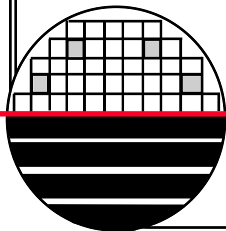


LIFT-OFF USING IMAGE REVERSAL RESIST

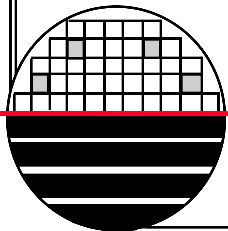
1. Coat wafers with n-LOF-2020 Image Reversal Resist, Use COATNLOF recipe on the SSI track
   HMDS prime: 140C, Dispense for 30s, Prime for 60s
   Manually dispense photoresist
   Spin at 2500 RPM, Spin for 60s, Thickness ~2500nm
   Soft Bake at 110C, Bake for 60s

2. Expose on the ASML Stepper – use same mask as for etch process (clear field mask)
   Dose = 66 mJ/cm^2 i-line (365nm), Focus = 1.5, NA = 0.60, Sigma=0.625

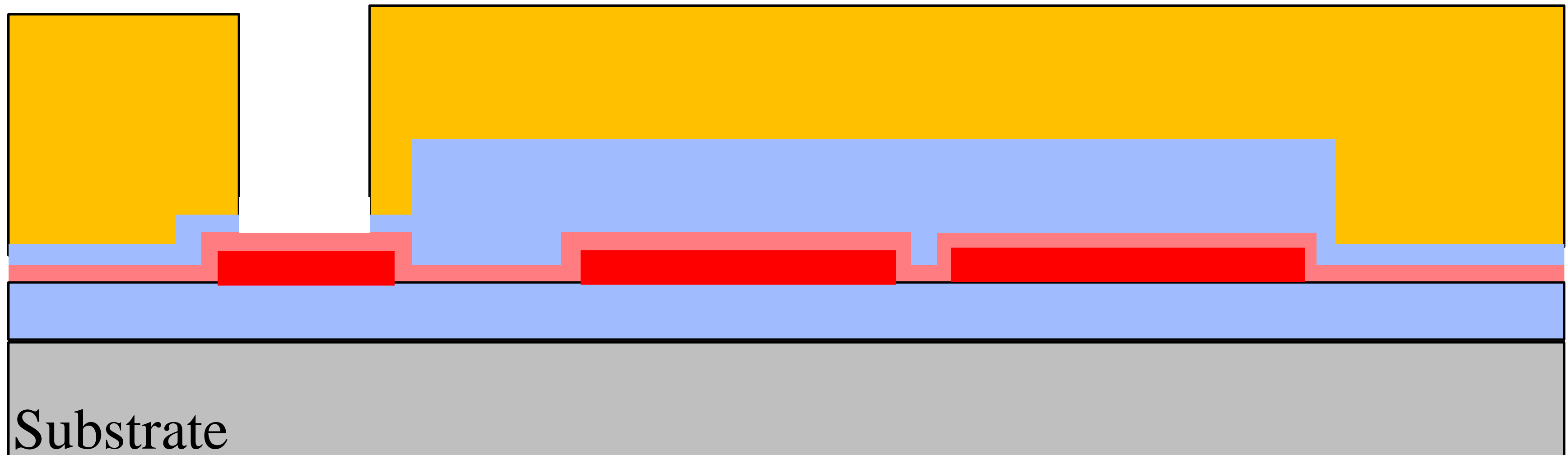
3. Develop on SSI Track using recipe DEVNLOF
   PEB (Image Reversal Bake) at 110C for 60s
   Spin and dispense developer for 5s, Dispense developer for 5s, Puddle develop for 70s
   Spin and rinse for 30s at 1000 RPM. Spin dry for 30s at 3750 RPM
   Do not hard bake. It can damage the sidewall profile. Hard Bake time = 0s

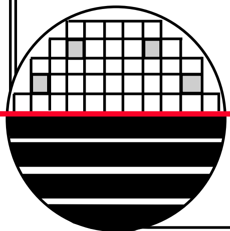
4. Etch

5. Remove Photoresist

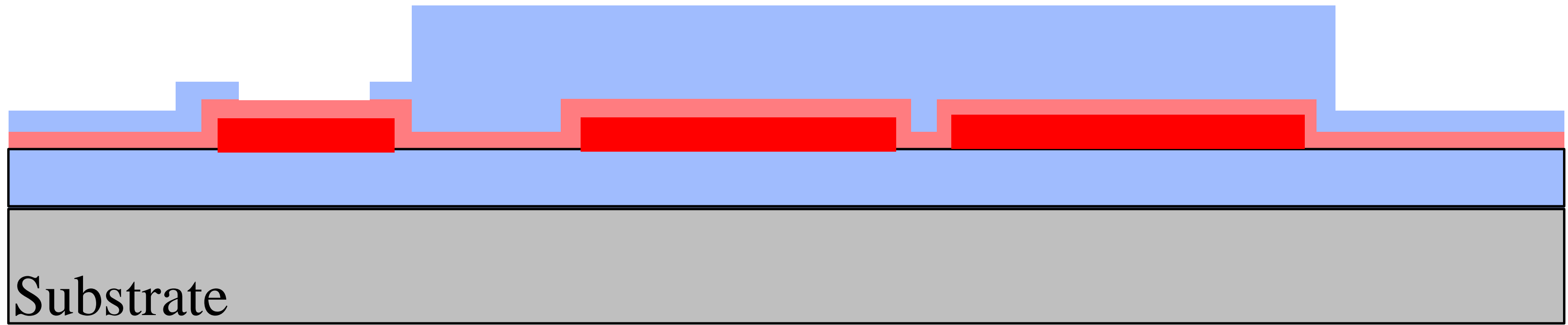


AFTER ANCHOR PHOTO AND ETCH

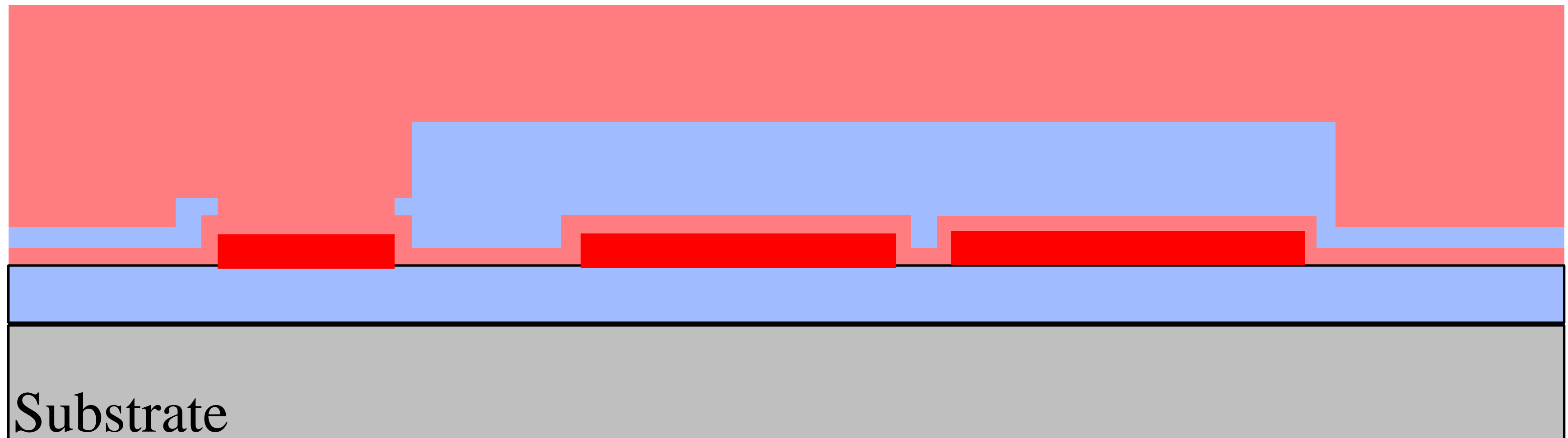




RESIST STRIP



DEPOSIT POLY 2 – MECHANICAL POLY



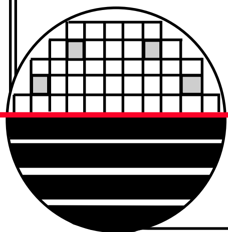
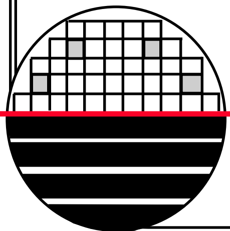


PHOTO – NO IMPLANT

Substrate



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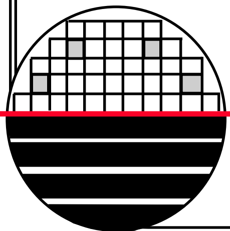
ION IMPLANT

Substrate

Ion Implant BF2
Dose = 2E16
Energy = 100KeV
Time ~?? min at 400 µA
Anneal Tube 2 Recipe ???



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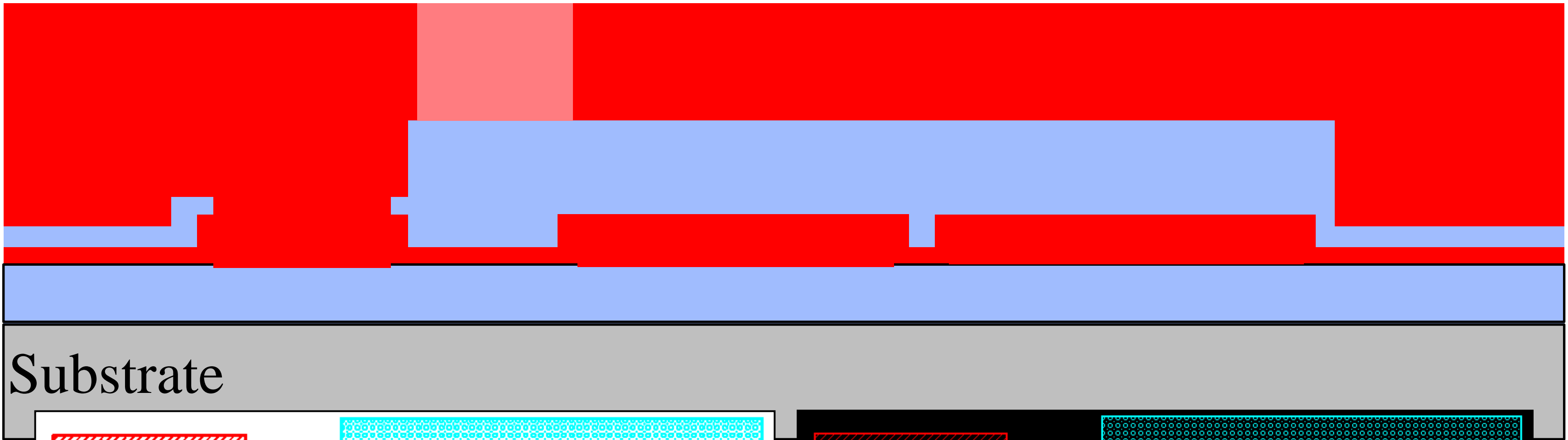
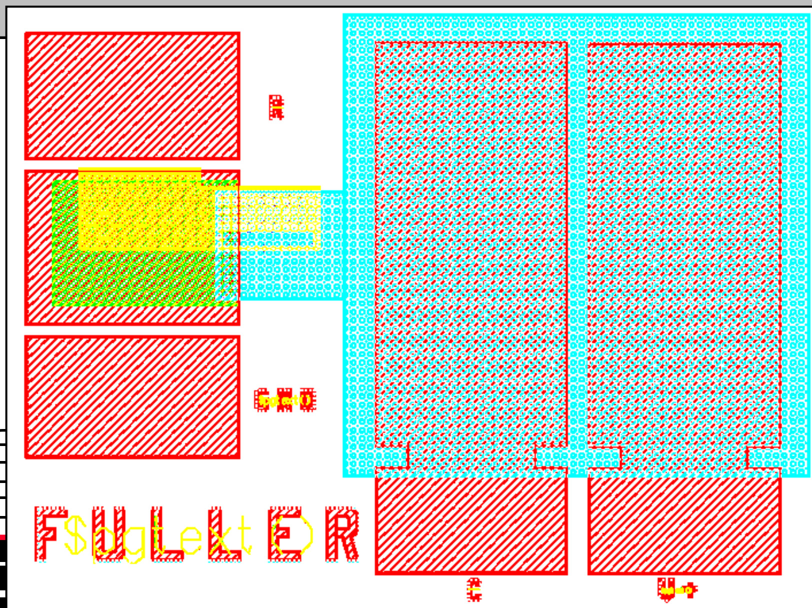
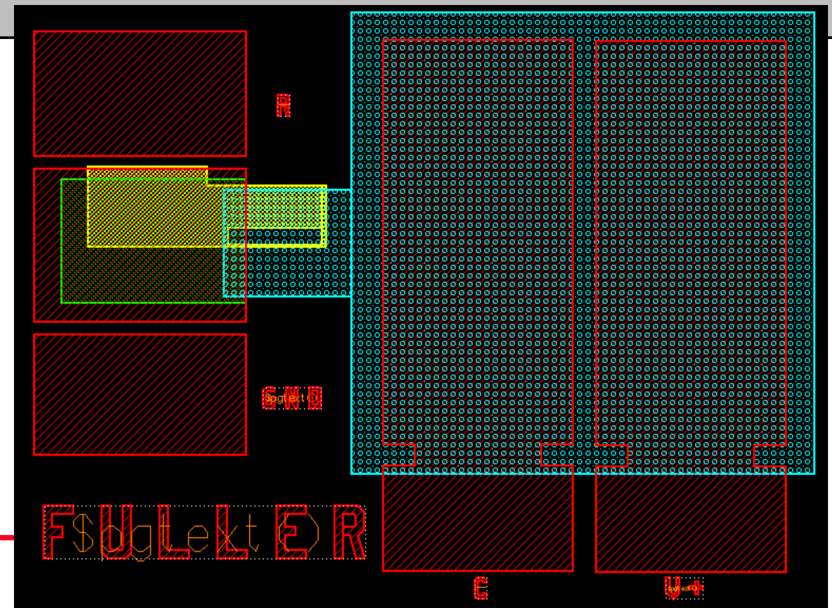
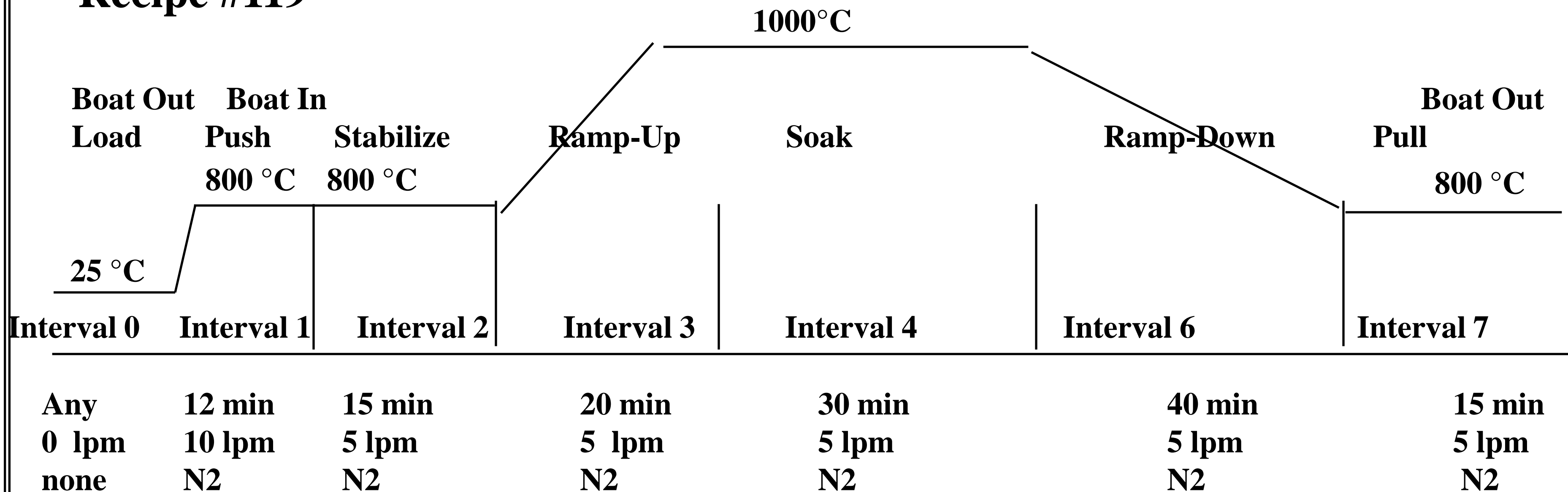
STRIP RESIST







BRUCE RECIPE 119 – N++ POLY DOPE/ANNEAL



At the end of a run the furnace returns to Interval 0 which is set for boat out, 25 °C and no gas flow. The furnace waits in that state until someone aborts the current recipe or loads a new recipe.

N+ Poly Doping/Anneal, Thick Poly, > 1 µm, No Oxide Growth

MEASURE POLY SHEET RESISTANCE

CDE Resistivity Mapper

CDE ResMap FileName: C:\4P\CDE_Demo.prj\6in49pt.rcp\3220K051.RsM
RunTitle CDE ResMap Demo Recipes

LotID,WaferID F021111D1 MyWafer
RunDate 10:05 02/20/03
Recip Name CDE_Demo 6in49pt
Oper|Engr[Equp]: CDE|Customer [ResMap]

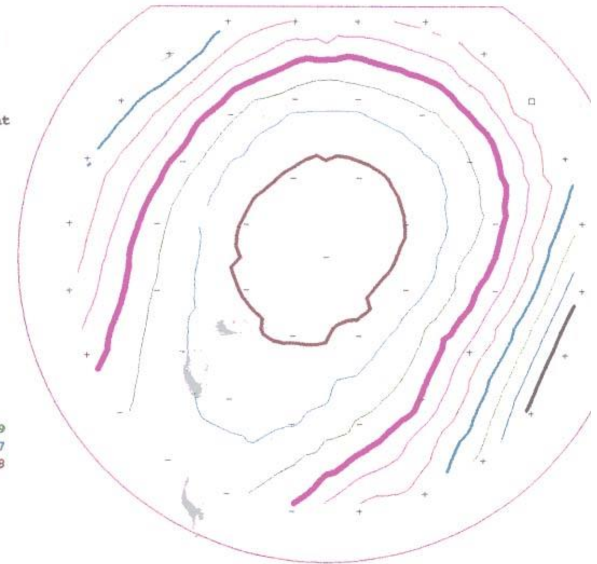
Wafer No. DualPrbCnfg
WaferDia 100 Flat
EdgeExclusn 8.0 FollowMajorFlat

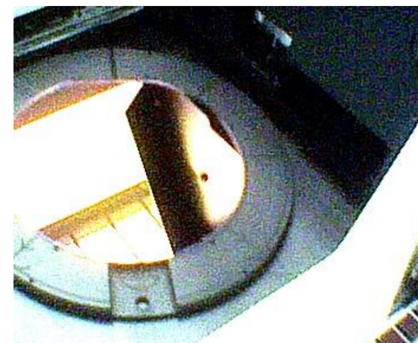
ProbePoints: 49 #Good: 48

Rs Avg 105.301 Ohms/sq
StdDev 10.5959 10.063% 3Sgma=30.188%
Min 90.039 Max 130.19 Range 40.156
(Mx-Mn)/(Mx+Mn) 18.23% (-)/2Av 19.07%
Lmin:14.49% Lmax:23.64% (-)/Av 38.13%
Gradients: R/2=7.652% ~R=22.245%
Merit: 61.6 21% 42.6 89.6
Rsns 10.0K IdvMx 0.74m VsnsMx 14.3m
DataRejectSigma: 3.0

#data=49 Rs Spacing = 1/3 Sigma

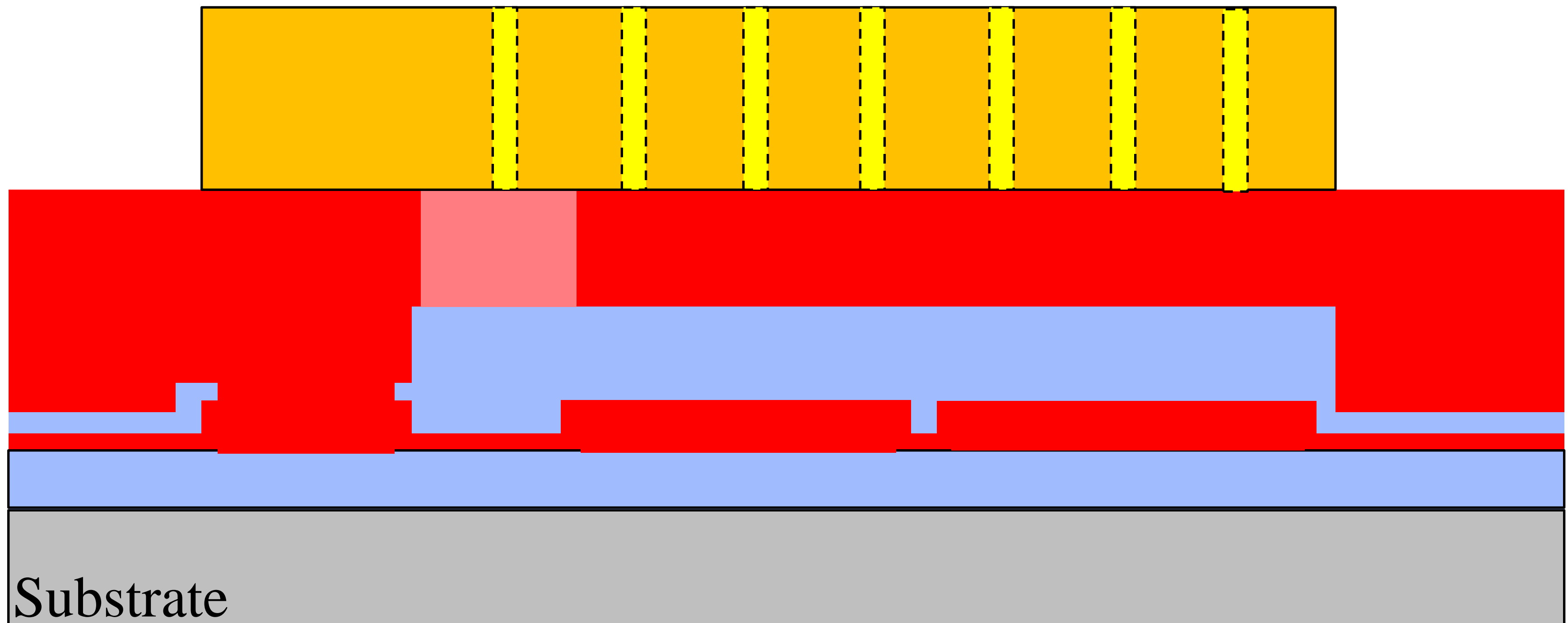
126.493
122.961
119.429
115.897
112.365
108.833
105.301
101.769
98.2367
94.7048



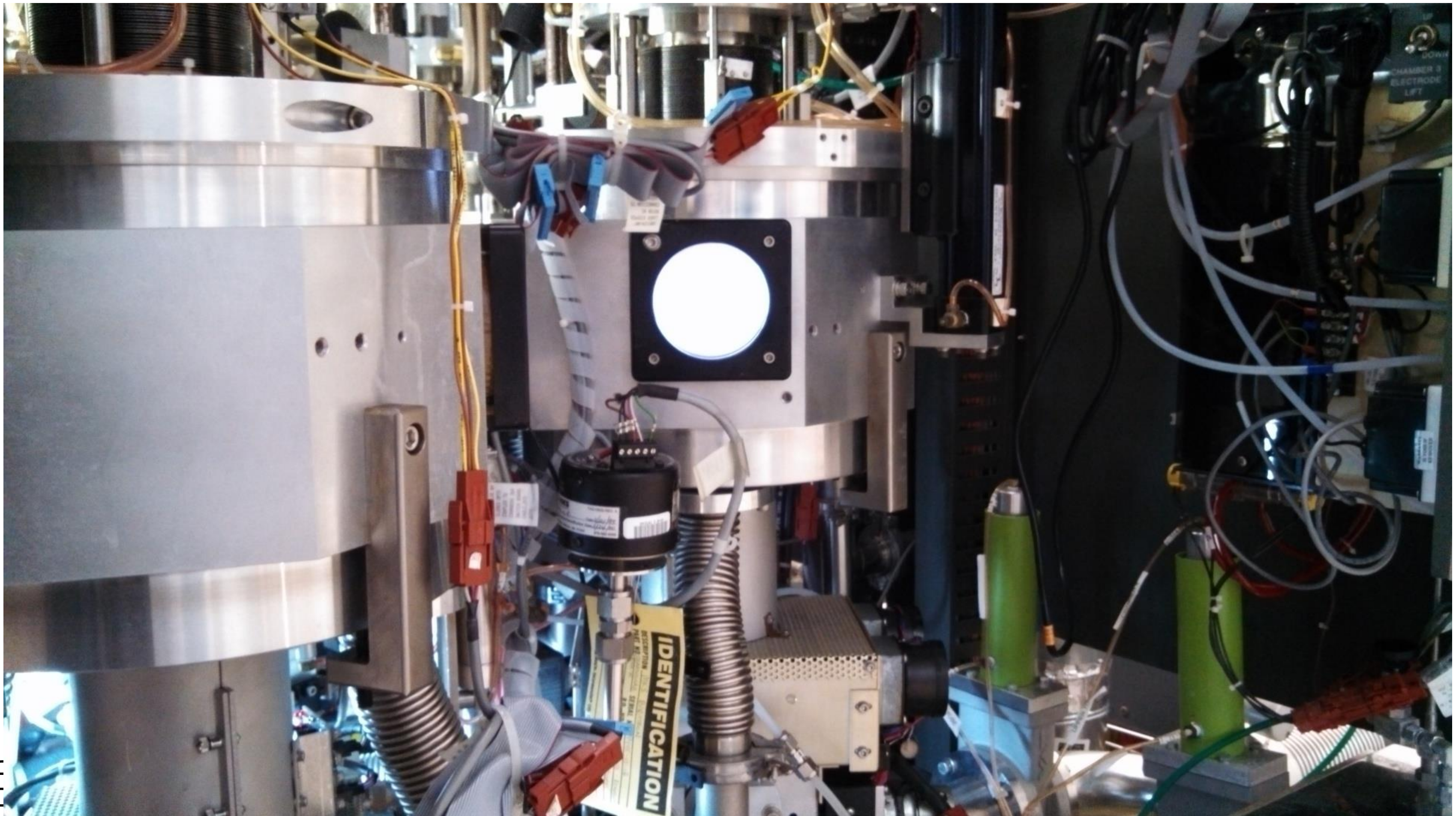


Rochester Institute of Technology
Microelectronic Engineering

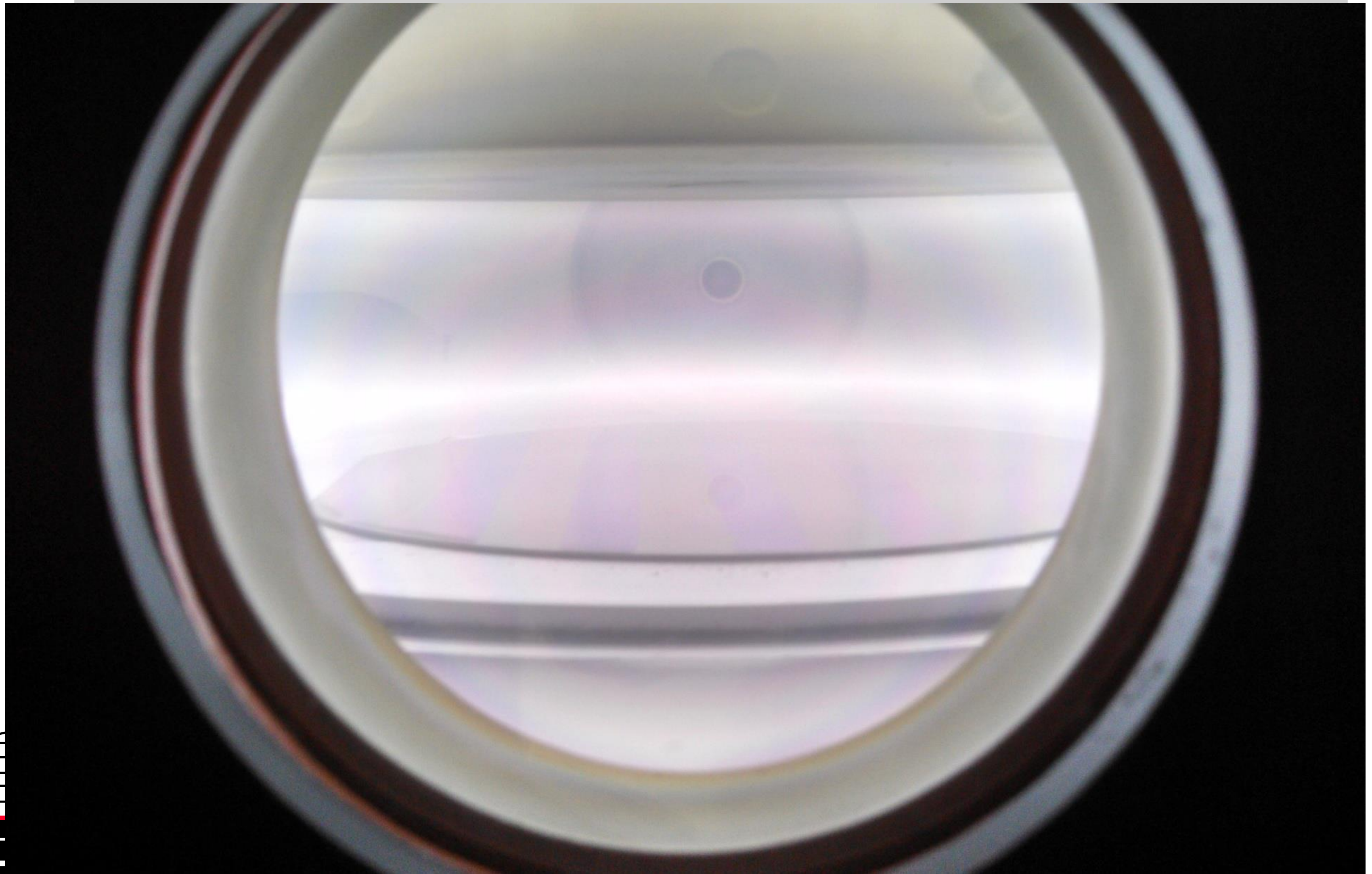
PHOTO FOR POLY 2



2 OF 4 CHAMBERS IN THE DRYTEK QUAD RIE TOOL



PLASMA ETCHING IN THE DRYTEK QUAD



ANISOTROPIC POLY GATE ETCH RECIPE

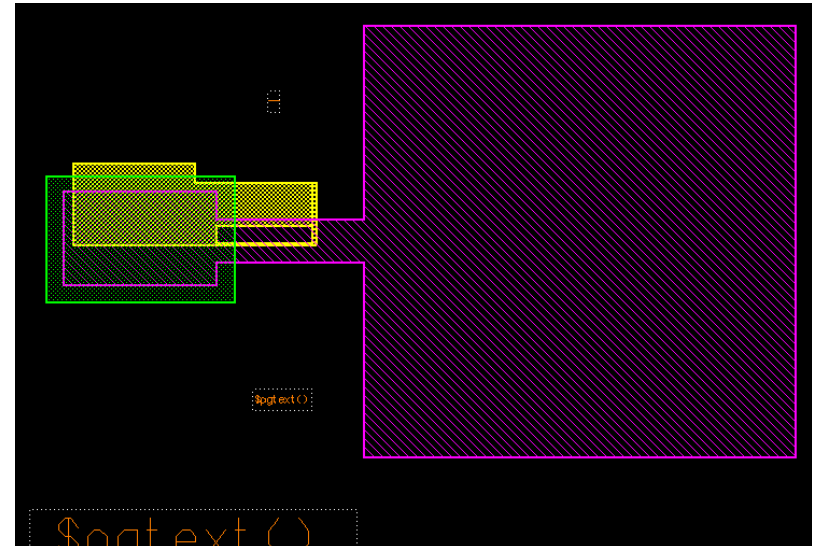
Anisotropic Poly Gate Etch Recipe

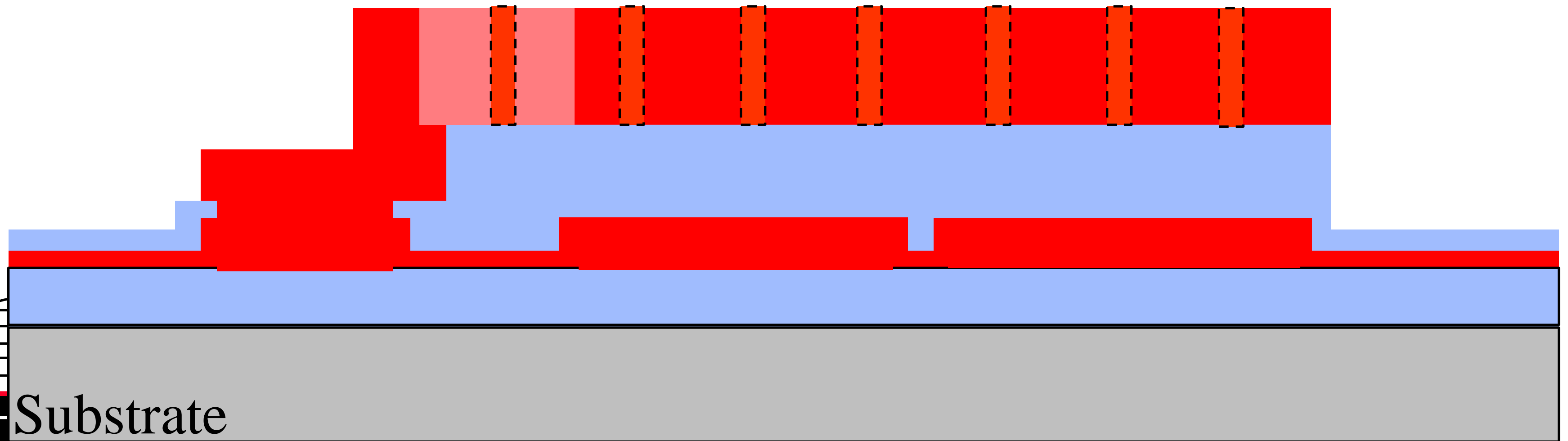
SF6 30 sccm, CHF3 30 sccm, O2 5 sccm, RF Power 160 w, Pressure 40 mTorr, 1900 A/min (Anisotropic), Resist Etch Rate 300 A/min, Oxide Etch Rate 200 A/min

Recipe Name:	FACPOLY Step 2
Chamber	2
Power	160 watts
Pressure	40 mTorr
Gas	SF6
Flow	30 sccm
Gas	CHF3
Flow	30 sccm
Gas	O2
Flow	5 sccm
Poly Etch Rate	1150 Å/min
Photoresist Etch Rate:	300 Å/min
Oxide Etch Rate:	200 Å/min

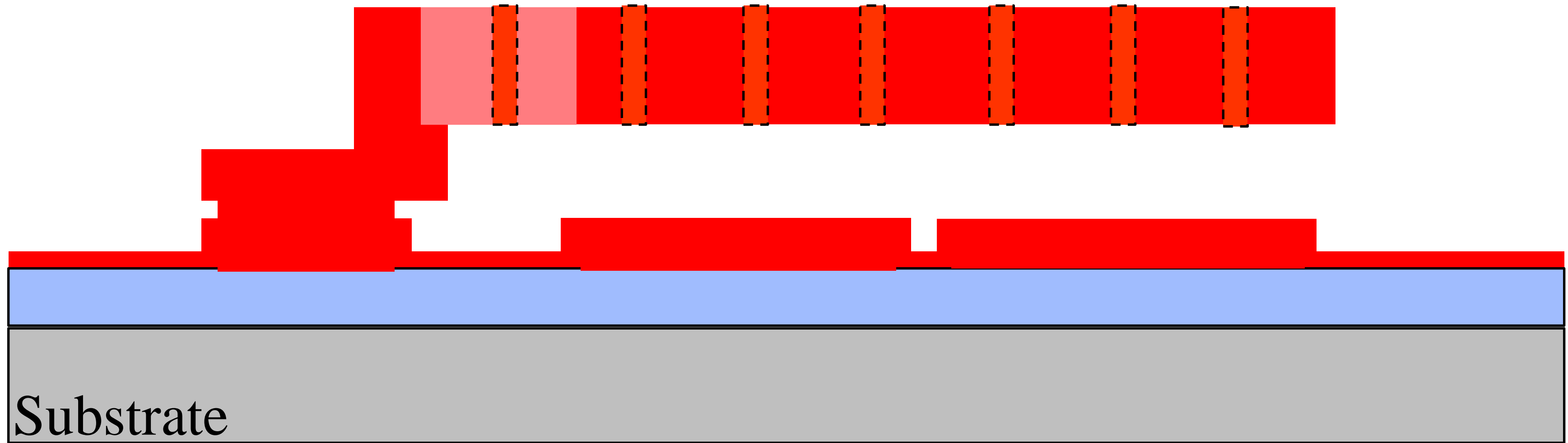
Endpoint See Video
http://people.rit.edu/lffeee/videos.htm

AFTER POLY 2 ETCH AND RESIST STRIP

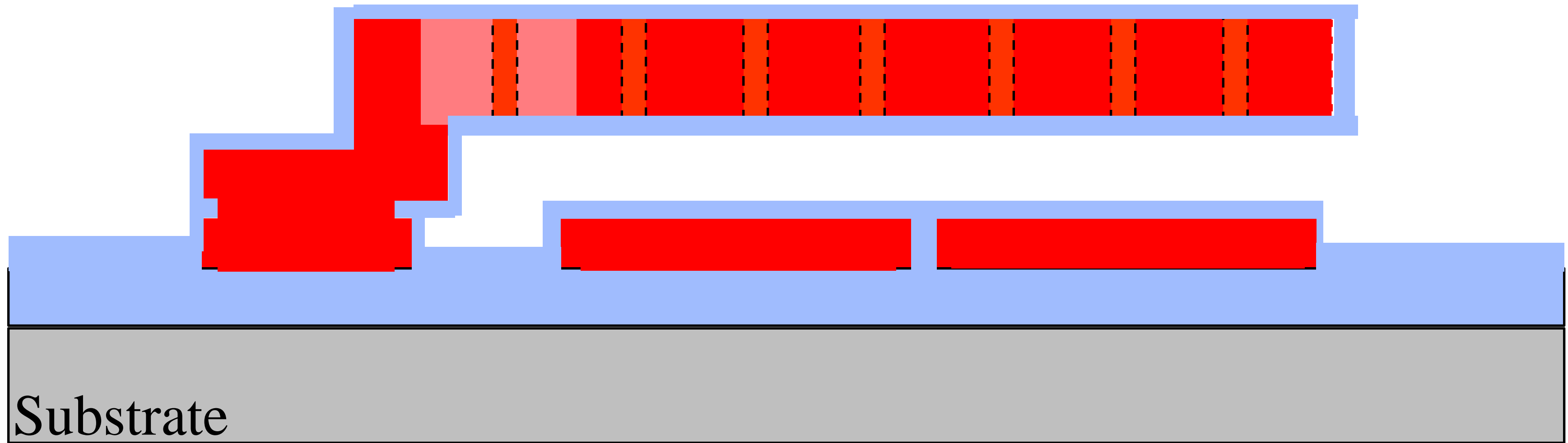




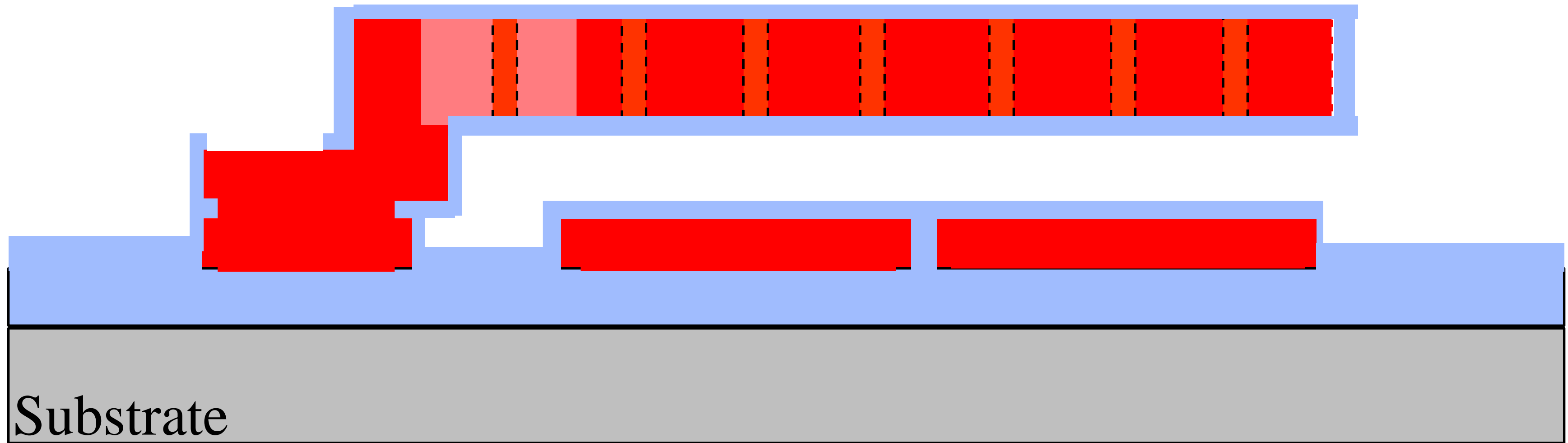
AFTER SAC OX ETCH



AFTER POLY REOX



CC



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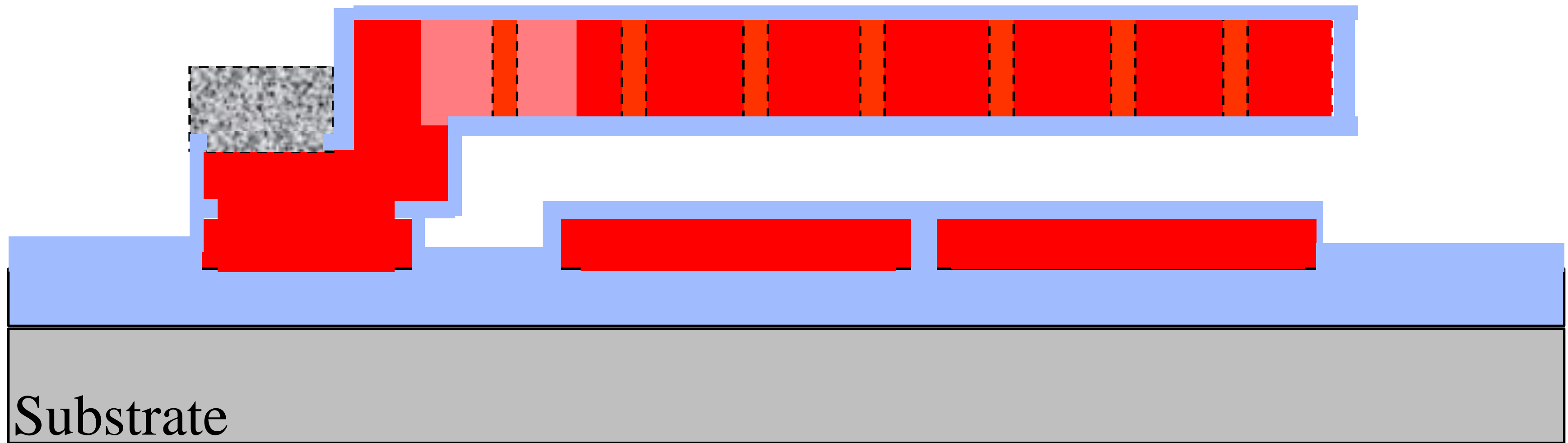
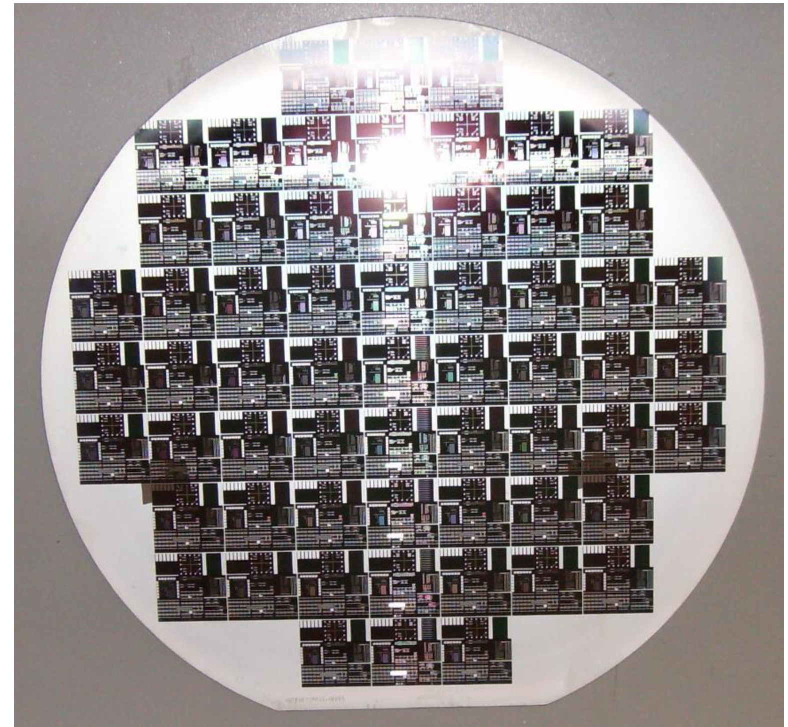
CANTILEVER, MIRROR OR ACCELEROMETER



ALUMINUM ETCH USING LAM4600

LAM4600



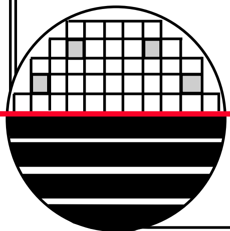
LAM4600 ANISOTROPIC ALUMINUM ETCH

Step	1	2	3	4	5
Pressure	100	100	100	100	0
RF Top (W)	0	0	0	0	0
RF Bottom	0	250	125	125	0
Gap (cm)	3	3	3	3	5.3
O2 111	0	0	0	0	0
N2 222	13	13	20	25	25
BCl 333	50	50	25	25	0
Cl2 444	10	10	30	23	0
Ar 555	0	0	0	0	0
CFORM666	8	8	8	8	8
Complete	Stabl	Time	Time	Oetch	Time
Time (s)	15	8	230	10%	15

Channel	B
Delay	130
Normalize	10 s
Norm Val	5670
Trigger	105%
Slope	+

Fuller, May 2010

SINTER



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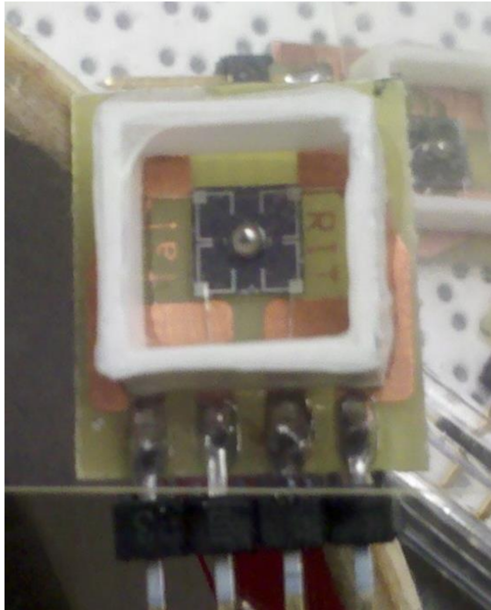
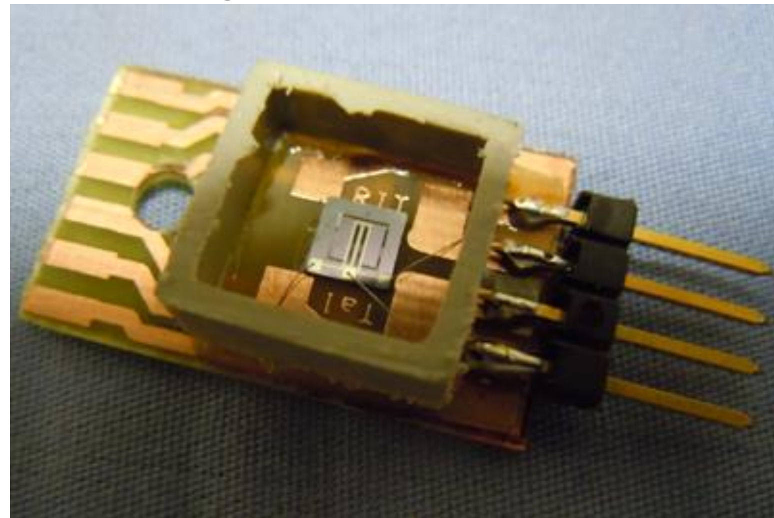
SOME EXAMPLES OF PACKAGED DEVICES

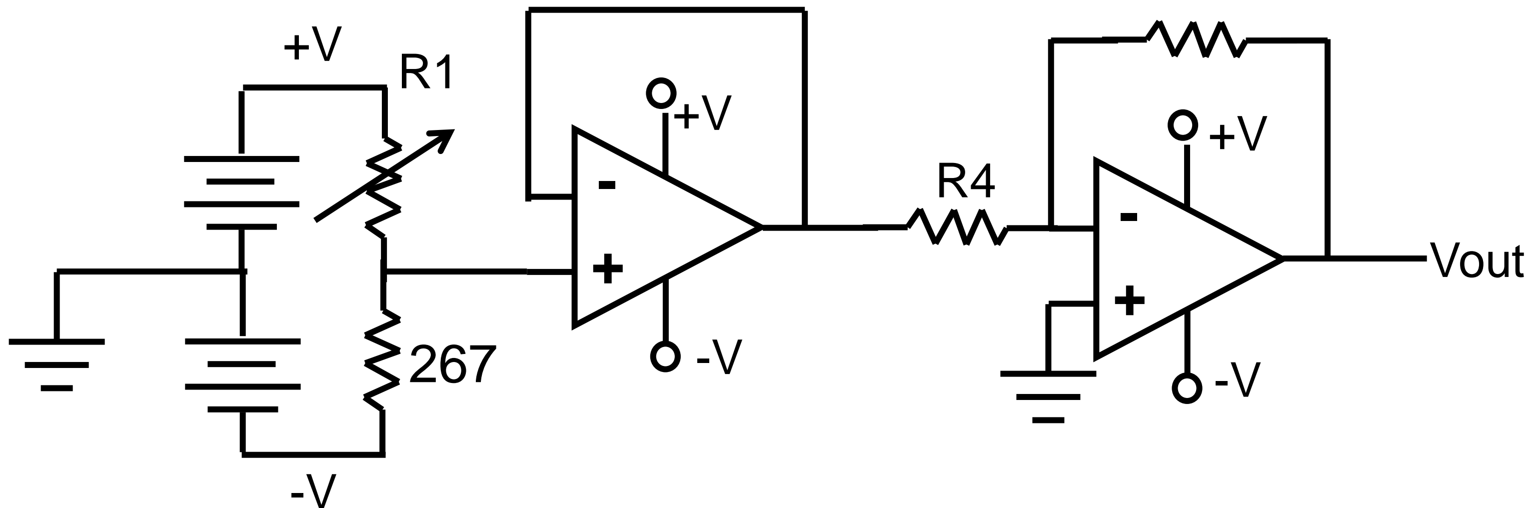
Magnetic Proximity Sensor



Packaged Accelerometer



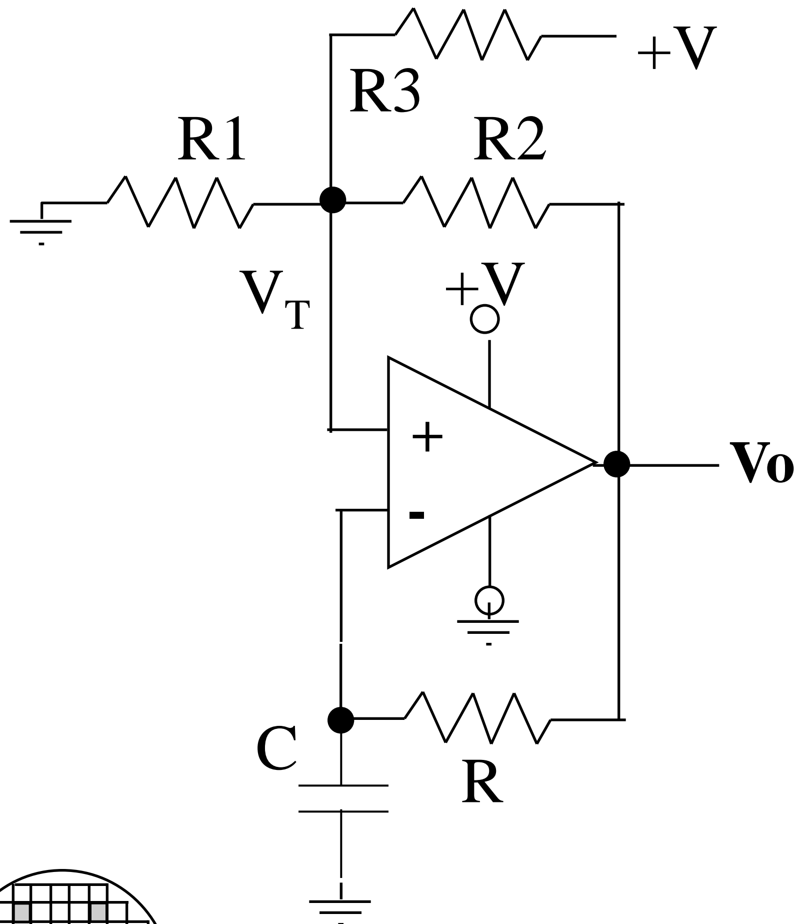
SINGLE RESISTOR SENSOR AMPLIFIER DESIGN

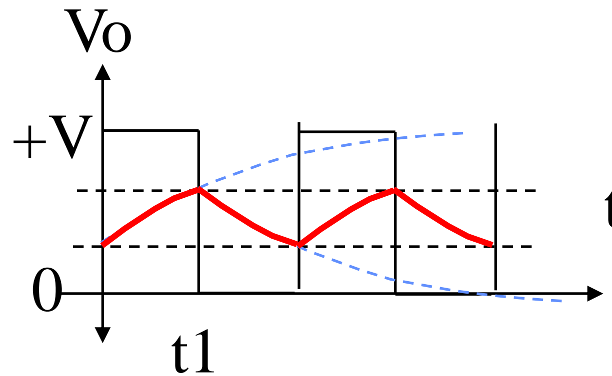


0.00004%/° C with gain of 1000 and 100C

$$Vout = \frac{V(1.004)}{(2.004 - {}^{1}/_{2})} = 3mV$$

SINGLE SUPPLY OSCILLATOR (MULTIVIBRATOR)

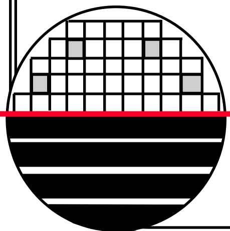




Let R1 = 100K, R2=R3=100K
and +V = 3.3
Then $V_T = 2.2$ when Vo = 3.3
$V_T = 1.1$ when Vo = 0

SUMMARY

CMOS Compatible?



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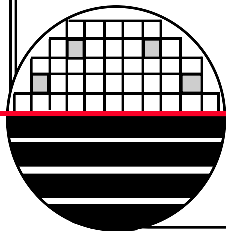
REFERENCES

1. Dr. Lynn Fuller's webpage
2. more



HOMEWORK – FABRICATION DETAILS

1. Draw a series of pictures that show the crossection and layout for your design project. From starting wafer to sinter. Not all of the 43 steps but for most of the steps.
2. Provide a list of all recipes and a short description.
3. What data should be collected ie. at step 7 record oxide thickness, at step 9 take picture of resolution, at step ? …..
4. Discuss how your device will be packaged.
5. Discuss how the devices you make will be tested. Describe any electronic circuits