MEMS Bulk Fabrication Process

Dr. Lynn Fuller, Ivan Puchades

Electrical and Microelectronic Engineering
Rochester Institute of Technology
82 Lomb Memorial Drive
Rochester, NY 14623-5604
Tel (585) 475-2035
Fax (585) 475-5041
Lynn.Fuller@rit.edu
http://www.microe.rit.edu

3-7-2014 MEMS_Bulk_Fabrication_Process.ppt

OUTLINE

Maskmaking
Alignment Details
Process Details
Packaging
Testing Approach
Test Results

DESIGN GUIDELINES

Microelectromechanical Systems

The basic unit of distance in a scalable set of design rules is called Lambda, λ

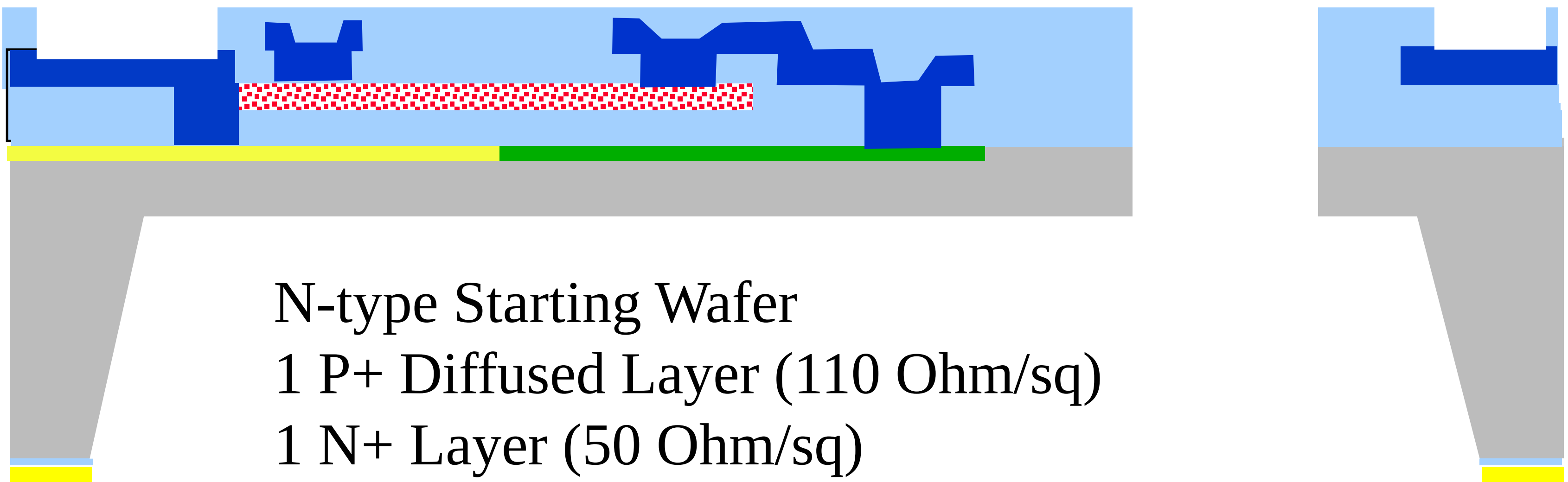
For the current MEMS process λ is ten microns (10 µm)

The process has eight mask layers, they are:

P+ Diffusion (Green)(layer 1)
N+ Diffusion (Yellow)(layer 2)
Poly Resistor (Red)(layer 3)
Contact (Gray)(layer 4)
Metal (Blue)(layer 5)
Diaphragm (Purple) (layer 6)
Top Via (White)(layer 7)

/shared/0305-870/mems_bulk_092

INTRODUCTION - RIT MEMS BULK PROCESS

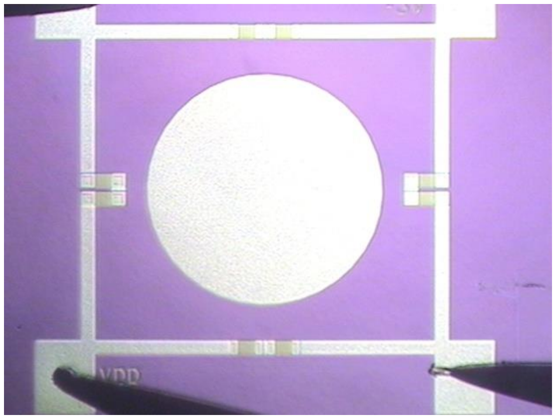


N-type Starting Wafer
1 P+ Diffused Layer (110 Ohm/sq)
1 N+ Layer (50 Ohm/sq)
1 N-Poly layer (40 Ohm/sq)
Contact Cuts
1 metal layer (Al 1µm thick)
Top Passivation and Top Hole
20-30 µm Si diaphragm

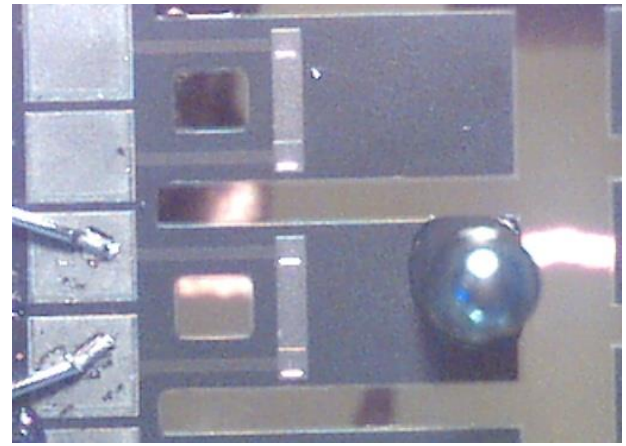
SOME POSSIBLE DEVICES

Pressure Sensor, diffused resistors or poly resistors
Microphone
Speaker – diaphragm with coil on it
Accelerometer – beam or mass on diaphragm
Diaphragm Actuator with coil or magnet with resistors for sensing and feedback
Thermally actuated membrane or beam
Optical pyrometer with thermocouples on diaphragm
Micro mirror with moving surfaces
Heater on diaphragm either poly or diffused resistor plus temp sensor
Heater plus interdigitated chemical sensor
Gas flow sensor single resistor anemometer
Gas flow sensor with heater and two resistors
PN junction temperature sensors

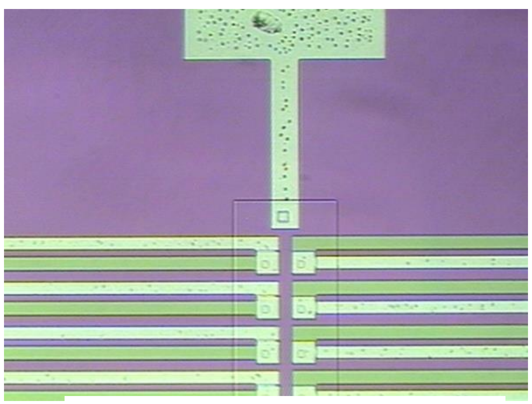
SOME EXAMPLES OF DEVICES



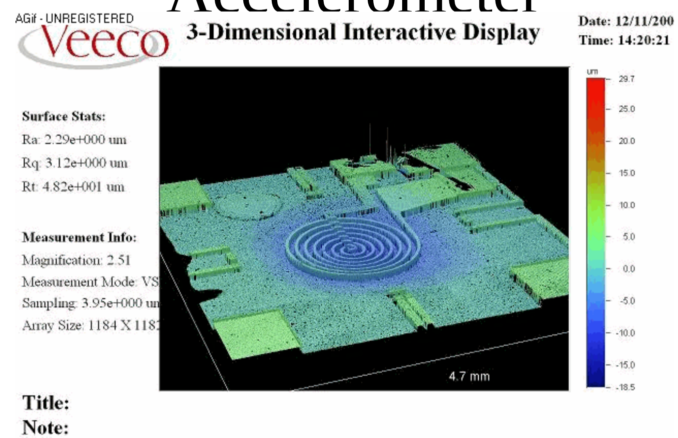
Pressure sensor



Accelerometer

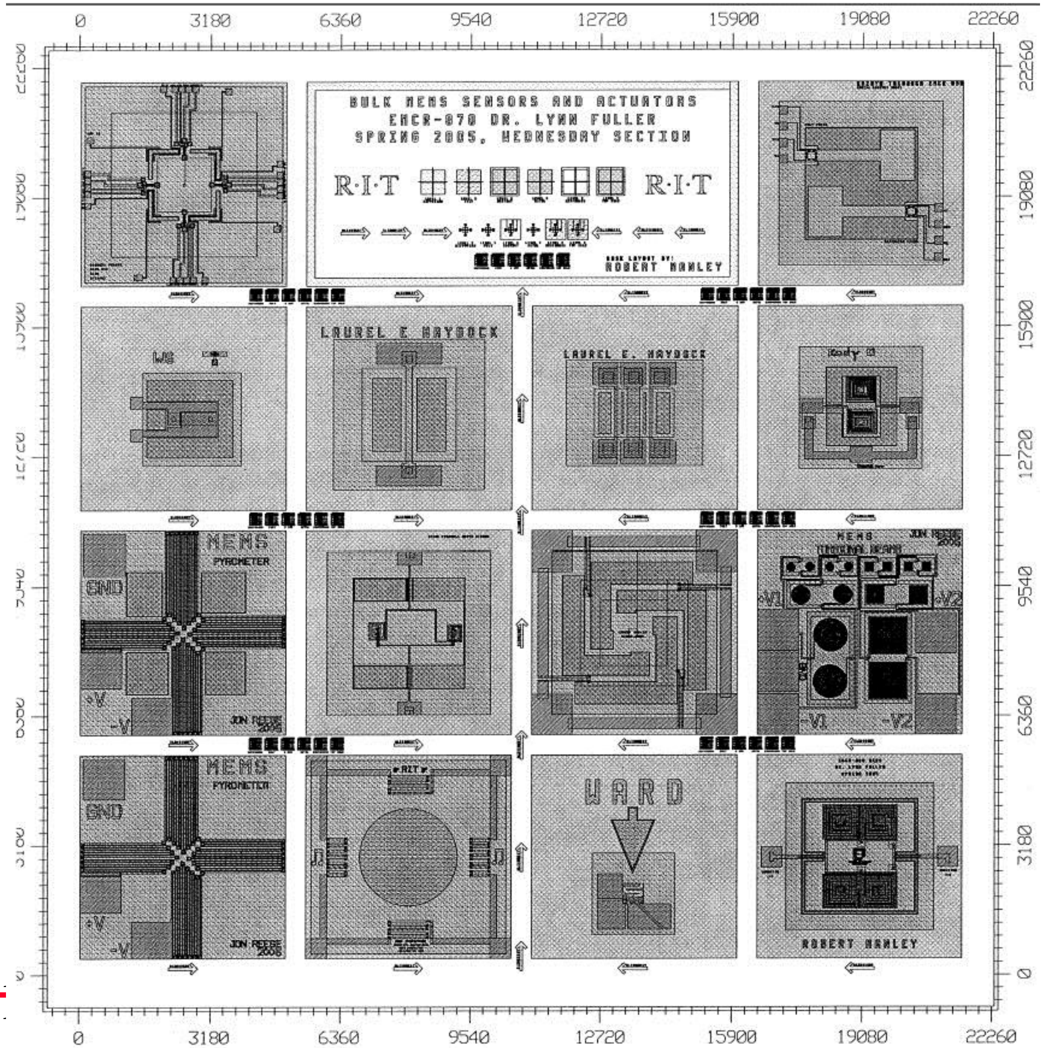


Thermocouples and Heater

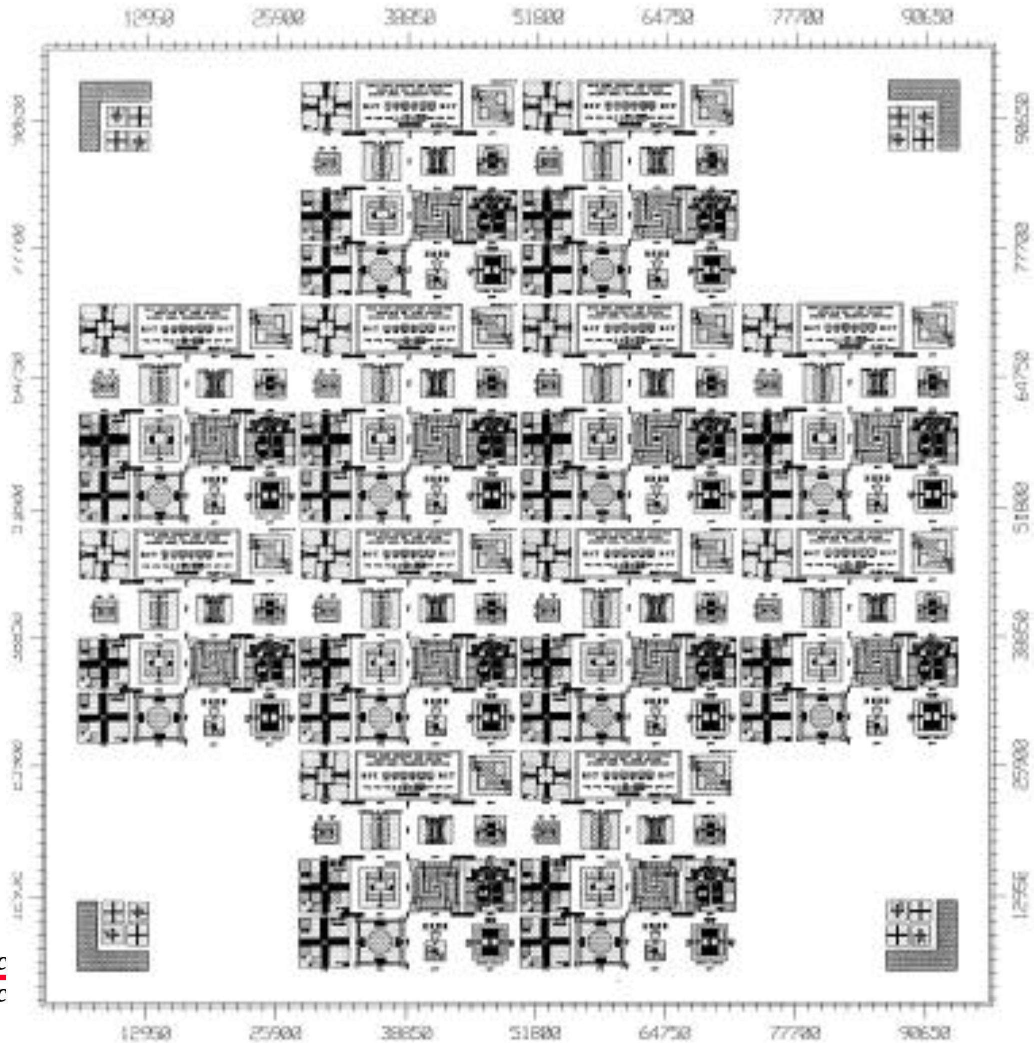


Micro-pump

MULTI CHIP PROJECT LAYOUT

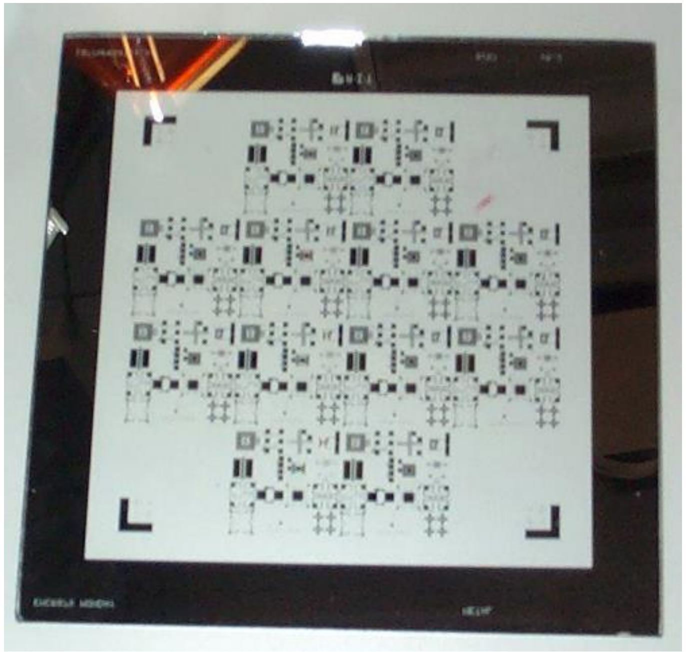


MASK LAYOUT



Roc
Mic

MASKS



ETCHED BULK MEMS PROCESS FLOW

1. Obtain qty 10, 4” n-type wafers
2. CMP back side
3. CMP Clean
4. RCA Clean
5. Grow masking oxide 5000 Å, Recipe 350
6. Photo 1: P++ diffusion
7. Etch Oxide, 12 min. Rinse, SRD
8. Strip Resist
9. Spin-on Glass, Borofilm 100, include dummy
10. Dopant Diffusion Recipe 110
11. Etch SOG and Masking Oxide, 20min BOE
12. Four Point Probe Dummy Wafer
13. RCA Clean
14. Grow 500 Å pad oxide, Recipe 250
15. Deposit 1500 Å Nitride
16. Photo 2: for backside diaphragm
17. Spin coat Resist on front side of wafer
18. Etch oxynitride, 1 min. dip in BOE, Rinse, SRD
19. Plasma Etch Nitride on back of wafer, Lam-490
20. Wet etch of pad oxide, Rinse, SRD
21. Strip Resist both sides
22. Etch Diaphragm in KOH, ~8 hours
23. Decontamination Clean
24. RCA Clean
25. Hot Phosphoric Acid Etch of Nitride
26. BOE etch of pad oxide
27. Grow 5000Å oxide
28. Deposit 6000 Å poly LPCVD
29. Spin on Glass, N-250
30. Poly Diffusion, Recipe 120
31. Etch SOG
32. 4 pt Probe
33. Photo 3, Poly
34. Etch poly, LAM490
35. Strip resist
36. RCA Clean
37. Oxidize Poly Recipe 250
38. Deposit 1µm LTO
39. Photo 4, Contact Cut
40. Etch in BOE, Rinse, SRD
41. Strip Resist
42. RCA Clean, include extra HF
43. Deposit Aluminum, 10,000Å
44. Photo 5, Metal
45. Etch Aluminum, Wet Etch
46. Strip Resist
47. Deposit 1µm LTO
48. Photo 6, Via
49. Etch Oxide in BOE, Rinse, SRD
50. Strip Resist
51. Deposit Aluminum, 10,000Å
52. Photo 7, Metal
53. Etch Aluminum, Wet Etch
54. Strip Resist
55. Deposit 1µm LTO
56. Deposit Aluminum, 10,000Å
57. Photo 8, Top Hole
58. Top hole aluminum etch
59. Diaphragm thinning option
60. Top hole Silicon etch
61. Test

STARTING WAFER

N – Type Starting Wafer
(100) Orientation
10 Ohm-cm
100mm (4-inch) Diameter
500um Thickness

WAFER THINNING AND BACKSIDE POLISH

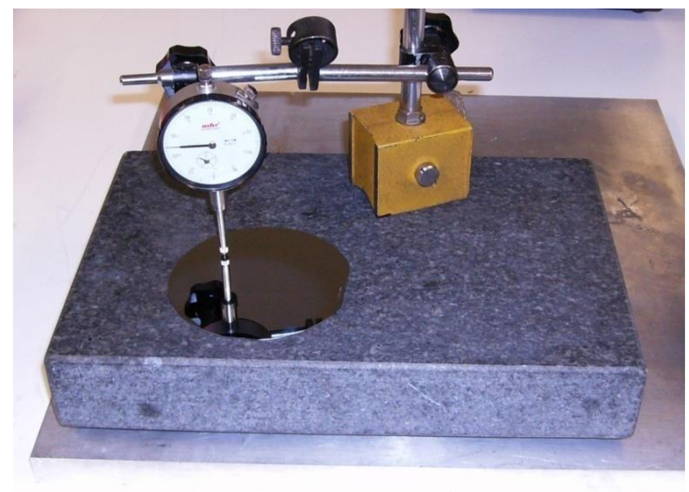
Wafers are often thinned before packaging. A thinner wafer allows for better heat removal, lower electrical resistance through the substrate and thinner packages. In MEMS wafer thinning allows for easier formation of thru wafer holes when combined with CMP double sided processing. We have been thinning our MEMS wafers from ~500µm down to ~300µm and then polishing to make thin double sided starting wafers.

We us our Electromet grinding tool and Strasbaugh CMP tool.

ELECTROMET GRINDING TOOL

Grinder

Platen Speed = 50 rpm
Pressure = 15 psi
Removal Rate = ~16µm/min
Time = 12 min (1200 setting)
Water On
Power in Auto



Wafer Thickness Measurement

GRINDING DISC - FROM GRAINGER

Home | Sign In | Your Account | Register   0 Items

GRAINGER
FOR THE ONES WHO GET IT DONE

Catalog 400   Find a Branch   Search

Products | Resources | Services | Worldwide | Repair Parts | About Us | Tod

PSA Disc, 8 D, 800 Grit, Diamond Abrasive

Power Tools & Metalworking > Finishing Supplies > Abrasive Adhesive Discs

PSA Disc, Dia 8 In, 800 Grit, Diamond Abrasive, For Use With Orbital Sanders or Vertical Shaft Grinders with PSA Back-Up Pads, For Grinding Glass, Ceramics and Composites

Grainger Item #	1KUY3
Price (ea.)	**$119.50**
Brand	NORTON
Mfr. Model #	66260306386
Ship Qty. ?	1
Sell Qty. (Will-Call) ?	1
Ship Weight (lbs.)	0.78
Usually Ships** ?	1-3 Days
Catalog Page No.	3107
Country of Origin	USA

Qty.

Add to Order | Add to Personal List | Compare Alternates

Price shown may not reflect your price. Sign in or register.

Tech Specs | Additional Information | Notes & Restrictions | MSDS

Item	PSA Disc
Dia. (In.)	8
Grit	800
Abrasive	Diamond
Package Quantity	1

CMP BACKSIDE OF WAFERS

Strassbaugh CMP Tool

CMP DETAILS

Strassbaugh CMP Tool

Slurry: Lavisil-50-054, with pH=12, 15 min per wafer Slurry drip rate: ~1 drop/second

Down Pressure = 8 psi

Quill Speed = 70 rpm

Oscillation Speed = 6 per min

Table Speed = 50 rpm (~10 Hz)

The quality of this polish must be very good. If after polish you can not visually tell the front from the back then it is good. Otherwise the subsequent nitride coating will not be good enough to act as an etch mask to KOH

CMP CLEAN AND DECONTAMINATION CLEAN

Used for CMP clean. Used as a soap with texwipe similar to cleaning dishes.

WRS-200

In Wet Etch II
Decontamination Clean
4500 ml DI
+ 900 ml H2O2
+ 900 ml HCl
70 °C, 20 min.

RCA CLEAN WAFERS

APM

H_2O – 4500ml
NH_4OH–300ml
H_2O_2 – 900ml
75 °C, 10 min.

→

DI water
rinse, 5 min.

→

H_20 - 50
HF - 1
60 sec.

→

DI water
rinse, 5 min.

→

HPM

H_2O–4500ml
HCL-300ml
H_2O_2 – 900ml
75 °C, 10 min.

→

DI water
rinse, 5 min.

→

SPIN/RINSE
DRY

What does RCA stand for?

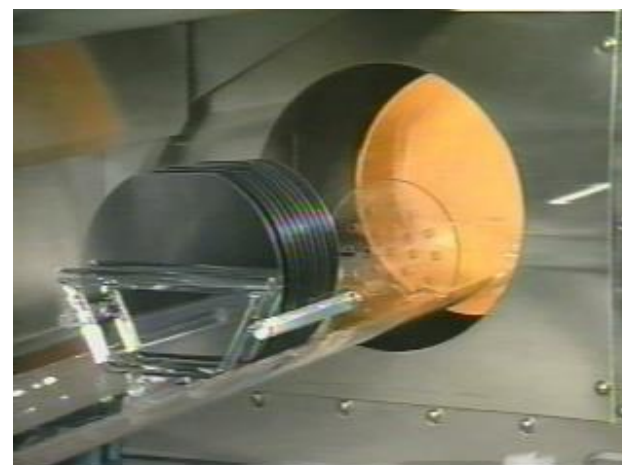
ANSWER

PLAY

Rochester Institute of Technology
Microelectronic Engineering

GROW 5000 Å OXIDE

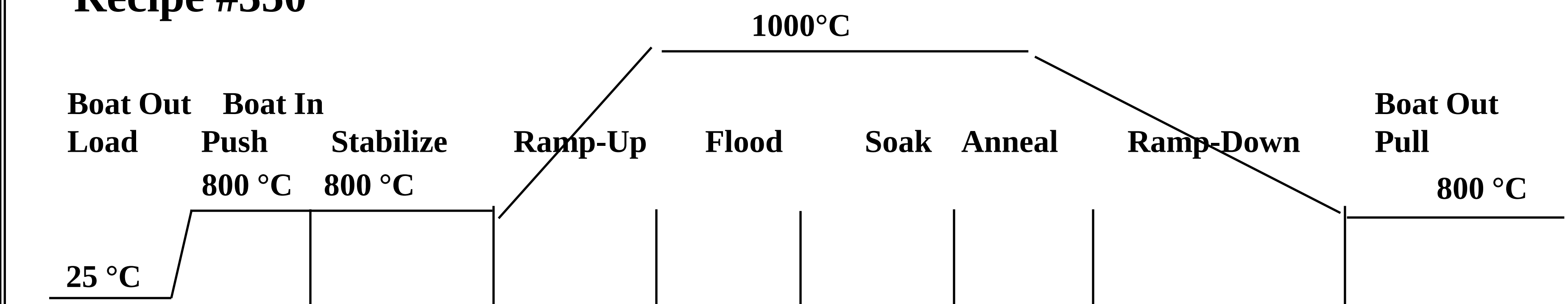
Masking Oxide, 5000 Å
Bruce Furnace 01, Recipe 350
1000 °C, 100 min.



Rochester Institute of Technology
Microelectronic Engineering

BRUCE FURNACE RECIPE 350

Recipe #350



Interval 0	Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7	Interval 8
Any	12 min	15 min	20 min	5 min	100min	5 min	40 min	12 min
0 lpm	10 lpm	10 lpm	5 lpm	5 lpm	10 lpm	15 lpm	10 lpm	15 lpm
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 5000 Å

Rochester Institute of Technology
Microelectronic Engineering

OXIDE THICKNESS COLOR CHART

Thickness	Color
500	Tan
700	Brown
1000	Dark Violet - Red Violet
1200	Royal Blue Blue
1500	Light Blue - Metallic Blue
1700	Metallic - very light Yellow Green
2000	LIght Gold or Yellow - Slightly Metallic
2200	Gold with slight Yellow Orange
2500	Orange - Melon
2700	Red Violet
3000	Blue - Violet Blue
3100	Blue Blue
3200	Blue - Blue Green
3400	Light Green
3500	Green - Yellow Green
3600	Yellow Green
3700	Yellow
3900	Light Orange
4100	Carnation Pink
4200	Violet Red
4400	Red Violet
4600	Violet
4700	Blue Violet

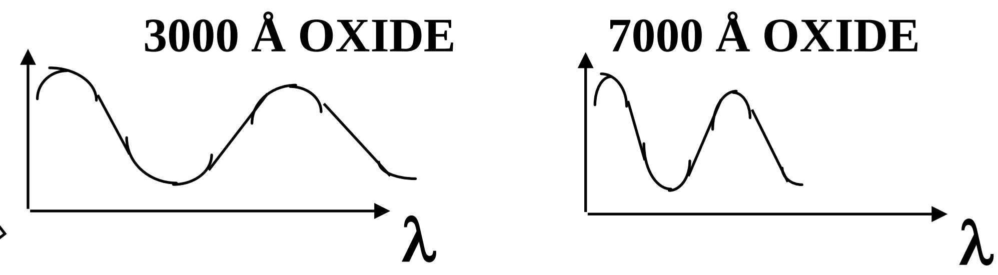
Thickness	Color
4900	Blue Blue
5000	Blue Green
5200	Green
5400	Yellow Green
5600	GreenYellow
5700	Yellow -"Yellowish"(at times appears to be Lt gray or matell
5800	Light Orange or Yellow - Pink
6000	Carnation Pink
6300	Violet Red
6800	"Bluish"(appears violet red, Blue Green, looks Blue
7200	Blue Green - Green
7700	"Yellowish"
8000	Orange
8200	Salmon
8500	Dull, LIght Red Violet
8600	Violet
8700	Blue Violet
8900	Blue Blue
9200	Blue Green
9500	Dull Yellow Green
9700	Yellow - "Yellowish"
9900	Orange
10000	Carnation Pink

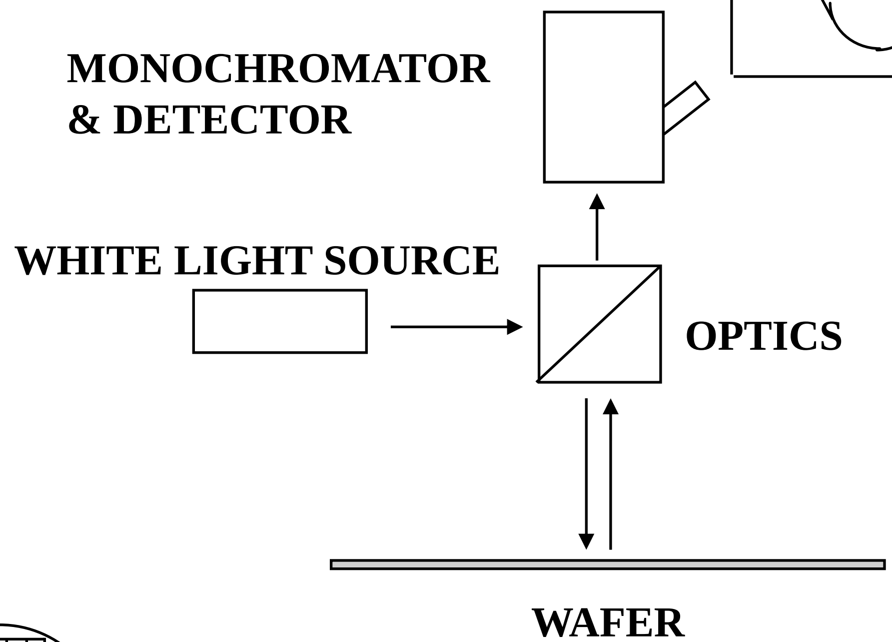
Nitride Thickness = (Oxide Thickness)(Oxide Index/Nitride Index)

Eg. Yellow Nitride Thickness = (2000)(1.46/2.00) = 1460

NANOSPEC THICKNESS MEASUREMENT (REFLECTANCE SPECTROMETER)

INCIDENT WHITE LIGHT, THE INTENSITY OF THE REFLECTED LIGHT IS MEASURED VS WAVELENGTH





Oxide on Silicon	400-30,000 Å
Nitride	400-30,000
Neg Resist	500-40,000
Poly on 300-1200 Ox	400-10,000
Neg Resist on Ox 300-350	300-3500
Nitride on Oxide 300-3500	300-3500
Thin Oxide	100-500
Thin Nitride	100-500
Polyimide	500-10,000
Positive Resist	500-40,000
Pos Resist on Ox 500-15,000	4,000-30,000

NANOSPEC FILM THICKNESS MEASUREMENT TOOL

WAFER AFTER OXIDE GROWTH

1st LAYER LITHOGRAPHY

The objective is to protect the oxide using photoresist prior to etching the pattern for the p+ diffused heaters, resistors and cross unders.

SVG COAT AND DEVELOP RECIPES

COAT

DEHYDRATE BAKE → COAT → SOFT BAKE

DEHYDRATE BAKE	COAT	SOFT BAKE
200 °C, 120 sec. Optional	HMDS Vapor Prime S-8 RESIST 4500 rpm, 60 sec.	90 °C 60 sec.

DEVELOP

POST EXPOSURE BAKE → DEVELOP → HARD BAKE

POST EXPOSURE BAKE	DEVELOP	HARD BAKE
115 °C, 60 sec. Optional	DI Wet CD-26 Developer 50 sec., Puddle Rinse, Spin Dry	125 °C, 60 sec.

COAT, EXPOSE AND DEVELOP TOOLS

SVG Coat and Develop Track

Karl Suss MA-150

AFTER PHOTO LEVEL 1

Photo 1: P+ Heaters, Resistors, and Cross Unders

Exposure Dose = 100 mJ/cm2
Time ~ =20 sec

AFTER BOE ETCH

Etch in 5.2:1 BHF, 7 min., Rinse, SRD

AFTER RESIST STRIP, RCA CLEAN AND SRD

Strip Resist – Branson Asher

PLASMA ASHER TOOL

O_2 + Energy = 2 O

O is reactive and will combine with plastics, wood, carbon, photoresist, etc.

RF Power = 500 watts
Heat Lamp = 500 watts for 10 sec.
O_2 Flow = 4500 sccm
Pressure = 4000 mTorr
Time ~ 2 min./wafer

Branson Asher

SPIN-ON P+ DOPANT SOURCE

Spin on dopant glass B-150

3000 rpm

60 sec

P+ DOPING OBJECTIVE

The objective is to dope the silicon p+ so it will be conductive. We will use a spin-on glass dopant source and high temperature diffusion process to allow dopant atoms to diffuse from the spin-on glass into the silicon. The spin-on glass will be etched off and the sheet resistance will be measured using a four point probe technique. Measured sheet resistance should be approximately than 110 ohms/square.

Spinner

Spin-on glass B150

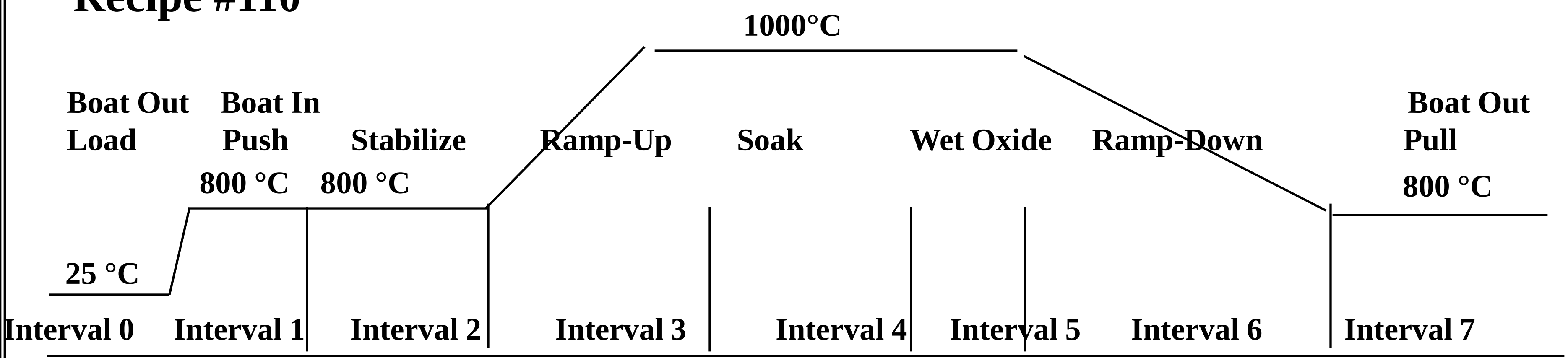
DIFFUSION

Diffusion: Drive in dopant
Recipe 110

BRUCE FURNACE RECIPE 110 P+ D/S &WET O2

Verified:2-24-04

Recipe #110



Interval 0	Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7
Any	12 min	15 min	20 min	20 min	30 min	40 min	12 min
0 lpm	10 lpm	10 lpm	10 lpm	10 lpm	2/3.6 lpm	10 lpm	5 lpm
none	N2	N2	N2	N2	O2/H2	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.

PMOS D/S Diffusion plusWet Oxide Growth

ETCH OFF SPIN ON GLASS (SOG)

Etch off SOG and all oxide – BHF
DI water rinse
Four point probe (Control)
RCA Clean
Spin Rinse Dry

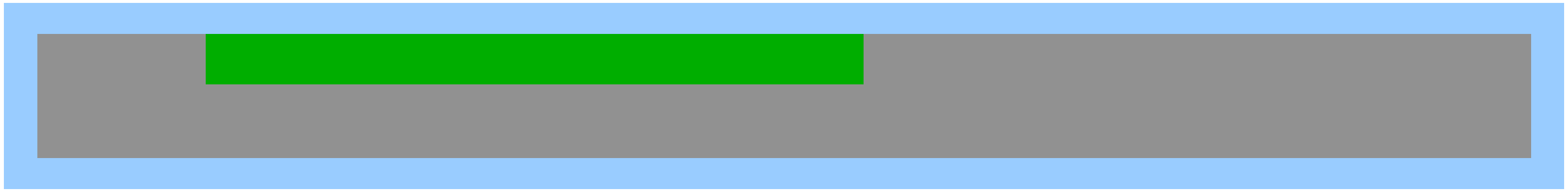
5.2:1 BOE
15 min.

Spin Rinse Dry
(SRD) Tool

Rochester Institute of Technology
Microelectronic Engineering

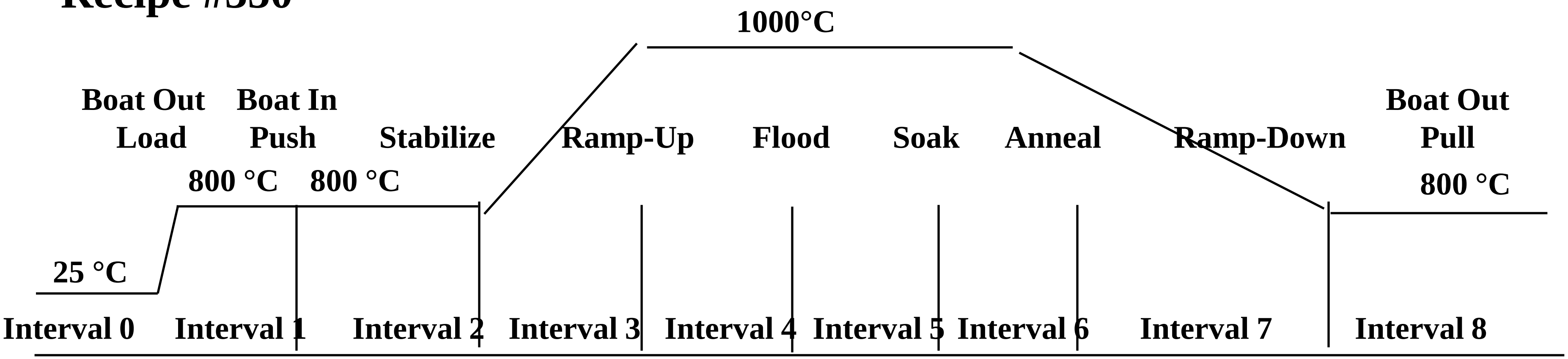
GROW MASKING OXIDE FOR N+ DIFFUSION

Masking Oxide, 5000 Å
Bruce Furnace 01, Recipe 350
1000 °C, 100 min.



BRUCE FURNACE RECIPE 350 – WET OXIDE 5,000Å

Recipe #350

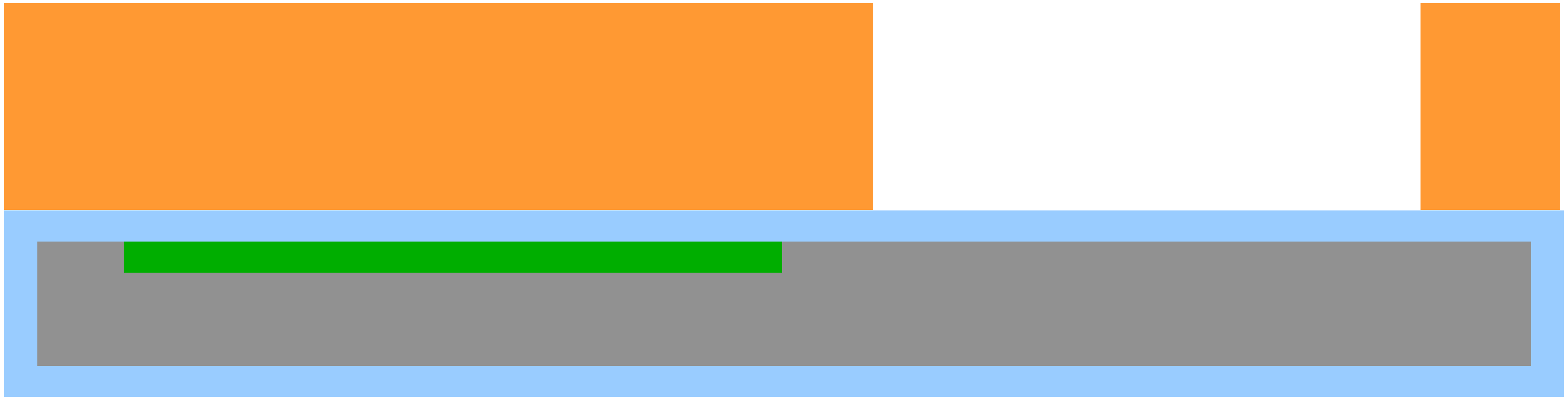


Any	12 min	15 min	20 min	5 min	100 min	5 min	40 min	12 min
0 lpm	10 lpm	10 lpm	5 lpm	10 lpm	3.6/2.0 lpm	15 lpm	10 lpm	5 lpm
none	N2	N2	N2	O2	O2/H2	N2	N2	N2

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.

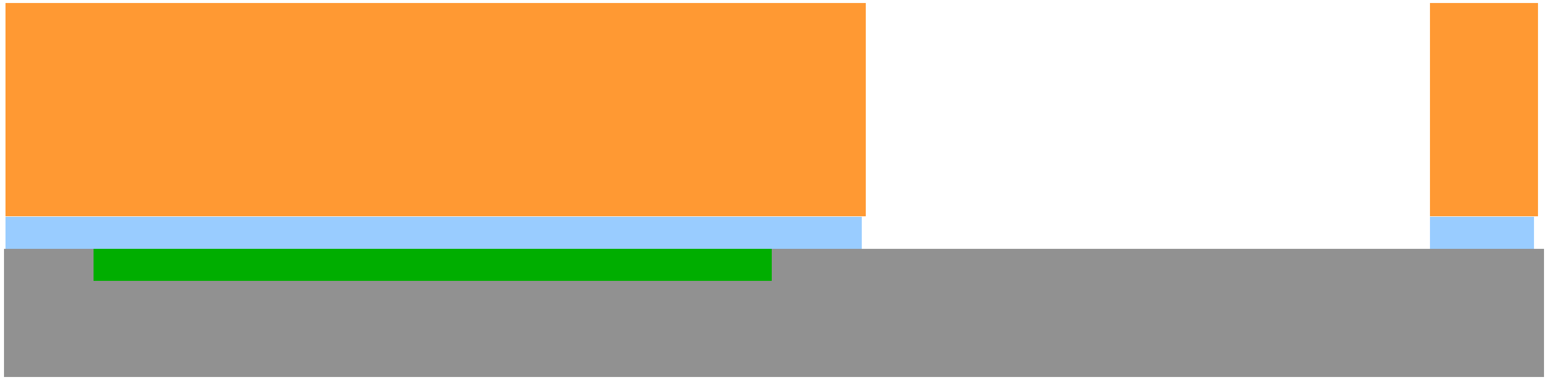
Wet Oxide Growth, Target 5000 Å

2^{ND} PHOTO – N+ DIFFUSION



Rochester Institute of Technology
Microelectronic Engineering

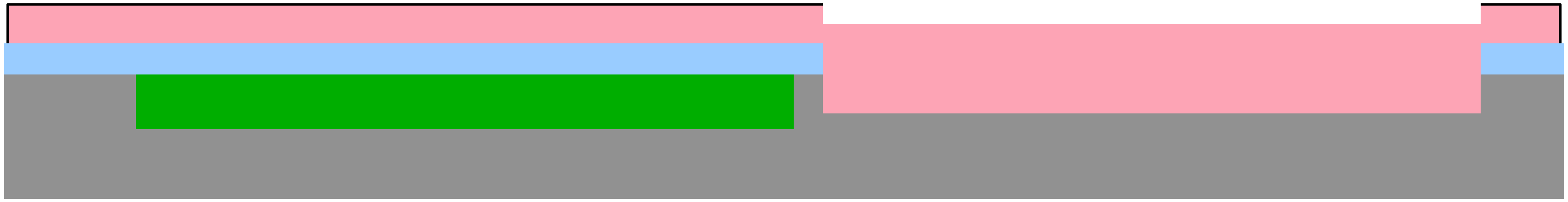
ETCH OXIDE, STRIP RESIST AND RCA CLEAN

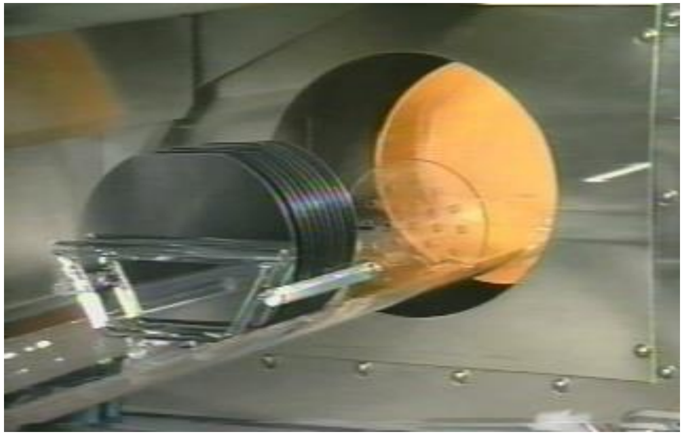


5.2:1 BOE 7 min.

SPIN ON N+ DOPANT AND DIFFUSION

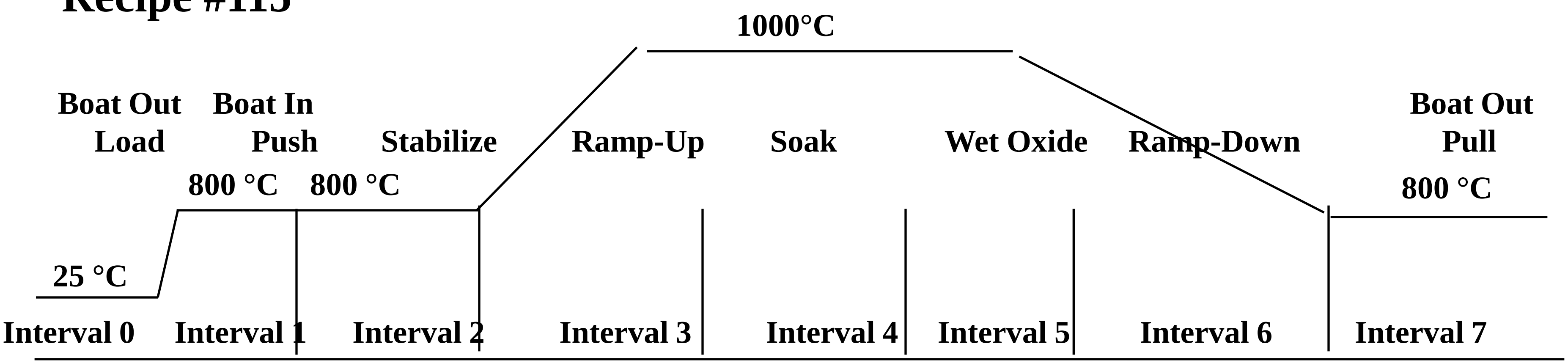
Dopant diffusion – recipe 115
Etch SOG and masking oxide
N+ 6.7ohm/sq, P+ 110ohm/sq





BRUCE FURNACE RECIPE 115 N+ DIFF &WET O2

Recipe #115

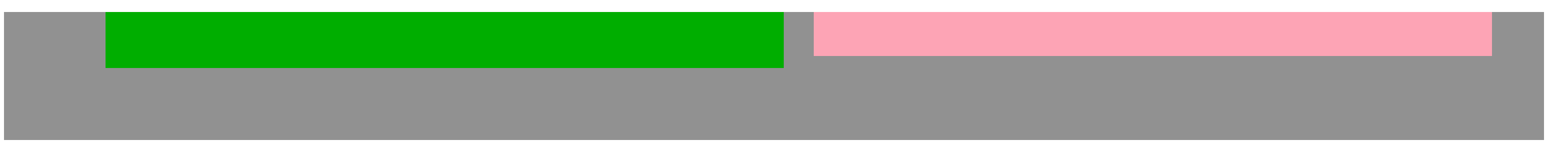


Any	12 min	15 min	20 min	30 min	30 min	40 min	12 min
0 lpm	10 lpm	10 lpm	10 lpm	10 lpm	2/3.6 lpm	10 lpm	5 lpm
none	N2	N2	N2	N2	O2/H2	N2	N2

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.

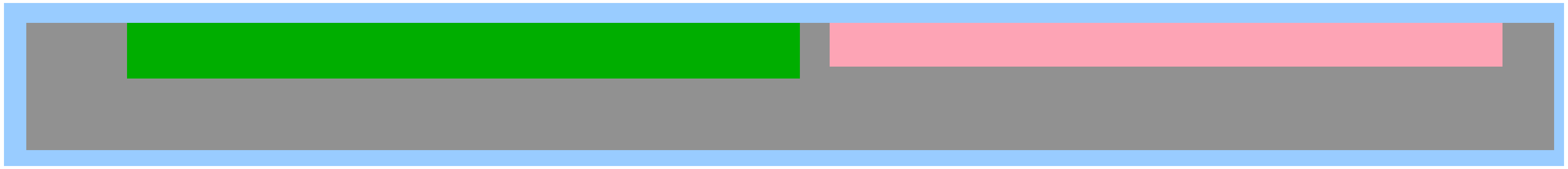
N+ Diffusion plus Wet Oxide Growth, Target 2854 Å

STRIP ALL OXIDE



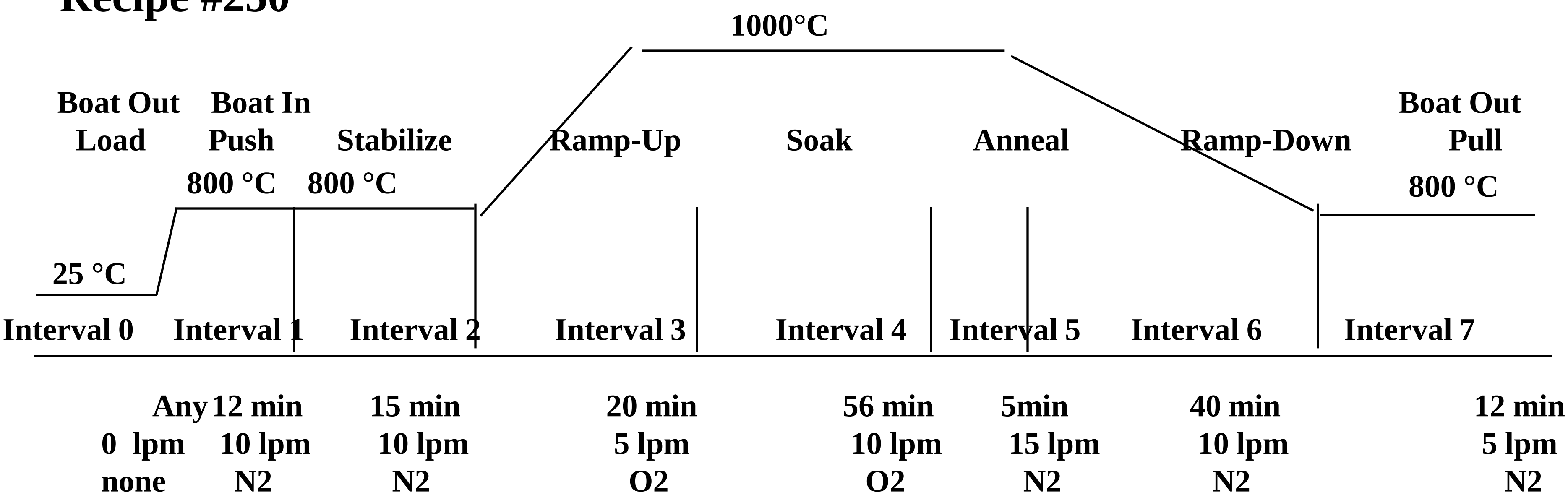
RCA CLEAN AND GROW 500Å OXIDE

Grow 500Å Pad oxide recipe 250
Target 500Å
Actual 800Å over N+ , 510Å over P+



BRUCE FURNACE RECIPE 250 - 500Å DRY OXIDE

Recipe #250

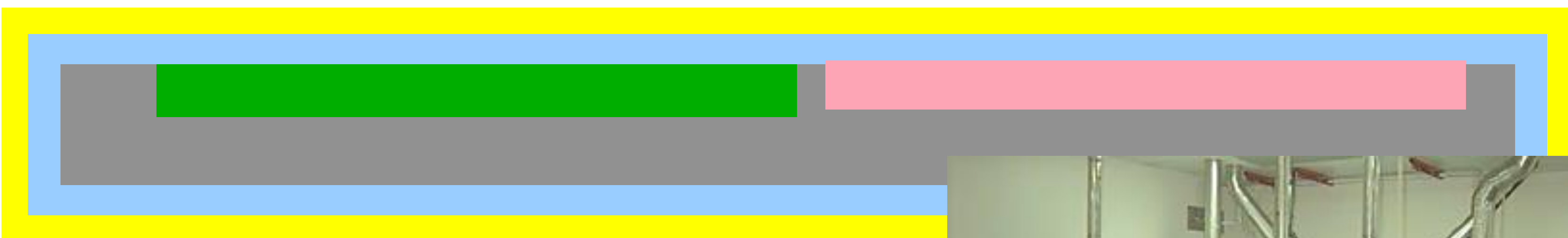


At the end of a run the furnace returns to Interval 0 which is set for boat out, 25 °C and no gas flow. The furnace waits in that state until someone aborts the current recipe or loads a new recipe.

Dry Oxide Growth, Target 500 Å

DEPOSIT PROTECTIVE SILICON NITRIDE LAYER

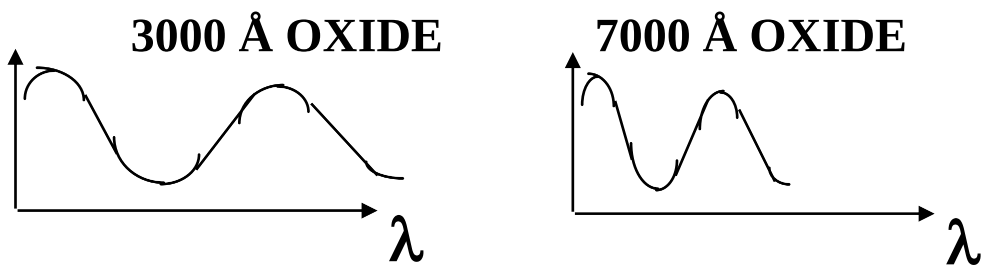
Silicon Nitride (Si_3N_4) (normal - stociometric):
Temperature = 790-800-810 °C Ramp from (door to pump)
Pressure = 375 mTorr $3SiH_2Cl_2 + 4NH_3 = Si_3N_4 + 9H_2 + 3Cl_2$
Dichlorosilane (SiH_2Cl_2) Flow = 60 sccm
Ammonia (NH_3) Flow = 150 sccm
Rate = 60 Å/min +/- 10 Å/min
Time ~25 min for 1500 Å

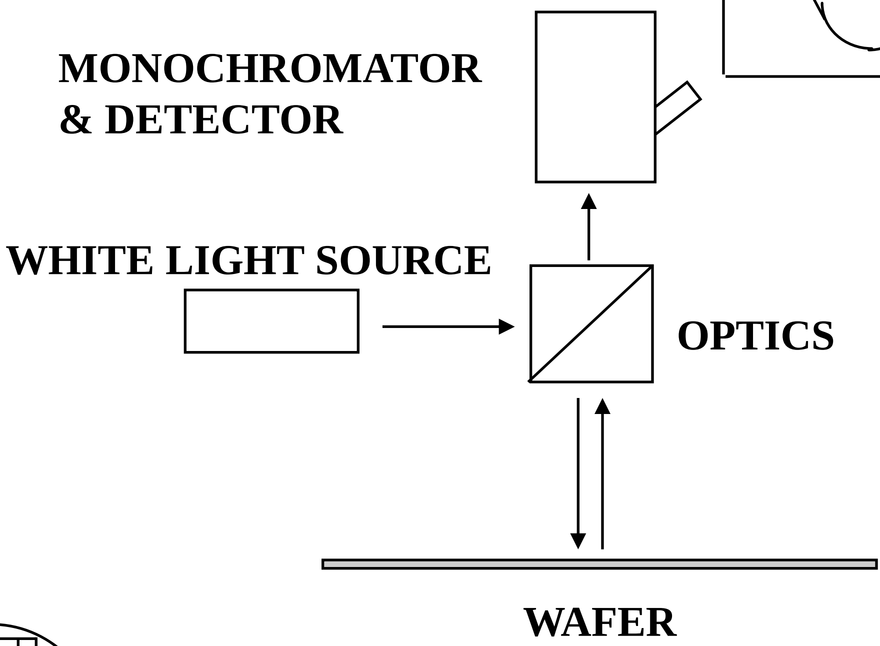


Rochester Institute of Technology
Microelectronic Engineering

NANOSPEC THICKNESS MEASUREMENT (REFLECTANCE SPECTROMETER)

INCIDENT WHITE LIGHT, THE INTENSITY OF THE REFLECTED LIGHT IS MEASURED VS WAVELENGTH





Oxide on Silicon	400-30,000 Å
Nitride	400-30,000
Neg Resist	500-40,000
Poly on 300-1200 Ox	400-10,000
Neg Resist on Ox 300-350	300-3500
Nitride on Oxide 300-3500	300-3500
Thin Oxide	100-500
Thin Nitride	100-500
Polyimide	500-10,000
Positive Resist	500-40,000
Pos Resist on Ox 500-15,000	4,000-30,000

NANOSPEC FILM THICKNESS MEASUREMENT TOOL

OXIDE THICKNESS COLOR CHART

Thickness	Color
500	Tan
700	Brown
1000	Dark Violet - Red Violet
1200	Royal Blue Blue
1500	Light Blue - Metallic Blue
1700	Metallic - very light Yellow Green
2000	LIght Gold or Yellow - Slightly Metallic
2200	Gold with slight Yellow Orange
2500	Orange - Melon
2700	Red Violet
3000	Blue - Violet Blue
3100	Blue Blue
3200	Blue - Blue Green
3400	Light Green
3500	Green - Yellow Green
3600	Yellow Green
3700	Yellow
3900	Light Orange
4100	Carnation Pink
4200	Violet Red
4400	Red Violet
4600	Violet
4700	Blue Violet

Thickness	Color
4900	Blue Blue
5000	Blue Green
5200	Green
5400	Yellow Green
5600	GreenYellow
5700	Yellow -"Yellowish"(at times appears to be Lt gray or matel
5800	Light Orange or Yellow - Pink
6000	Carnation Pink
6300	Violet Red
6800	"Bluish"(appears violet red, Blue Green, looks Blue
7200	Blue Green - Green
7700	"Yellowish"
8000	Orange
8200	Salmon
8500	Dull, LIght Red Violet
8600	Violet
8700	Blue Violet
8900	Blue Blue
9200	Blue Green
9500	Dull Yellow Green
9700	Yellow - "Yellowish"
9900	Orange
10000	Carnation Pink

Nitride Thickness = (Oxide Thickness)(Oxide Index/Nitride Index)

Eg. Yellow Nitride Thickness = (2000)(1.46/2.00) = 1460

3RD LAYER LITHOGRAPHY

The objective is to protect the nitride using photoresist on the front side of the wafer prior to etching the pattern for the diaphragm holes in the nitride on the back of the wafers.

SVG COAT AND DEVELOP RECIPES

COAT

DEHYDRATE BAKE	COAT	SOFT BAKE
200 °C, 120 sec. Optional	HMDS Vapor Prime S-8 RESIST 4500 rpm, 60 sec.	90 °C 60 sec.

DEVELOP

POST EXPOSURE BAKE	DEVELOP	HARD BAKE
115 °C, 60 sec. Optional	DI Wet CD-26 Developer 50 sec., Puddle Rinse, Spin Dry	125 °C, 60 sec.

COAT, EXPOSE AND DEVELOP TOOLS

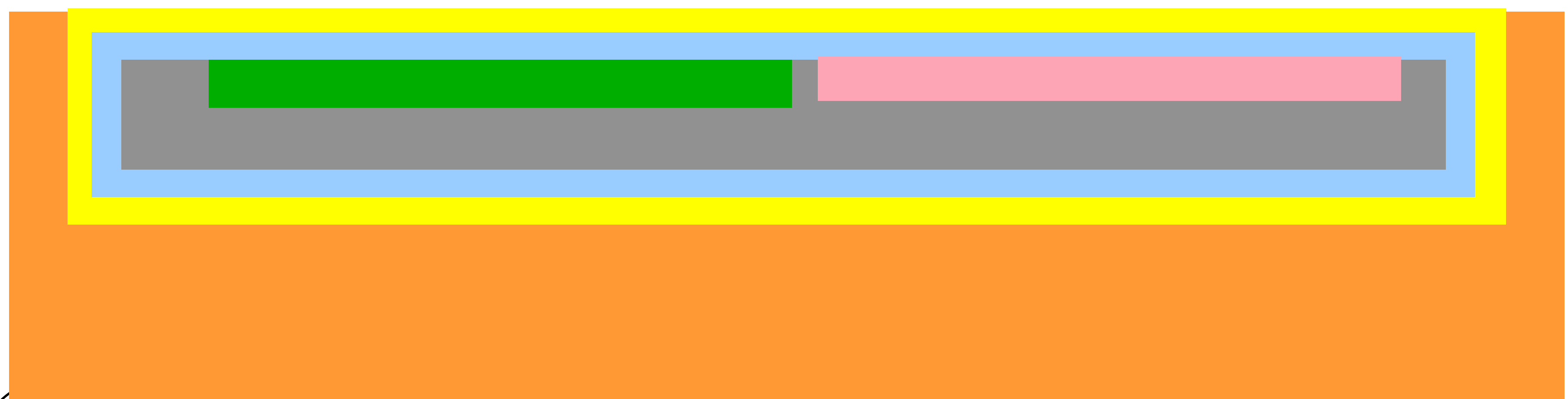
SVG Coat and Develop Track

Karl Suss MA-150

Rochester Institute of Technology
Microelectronic Engineering

SPIN COAT THE BACK SIDE OF WAFER

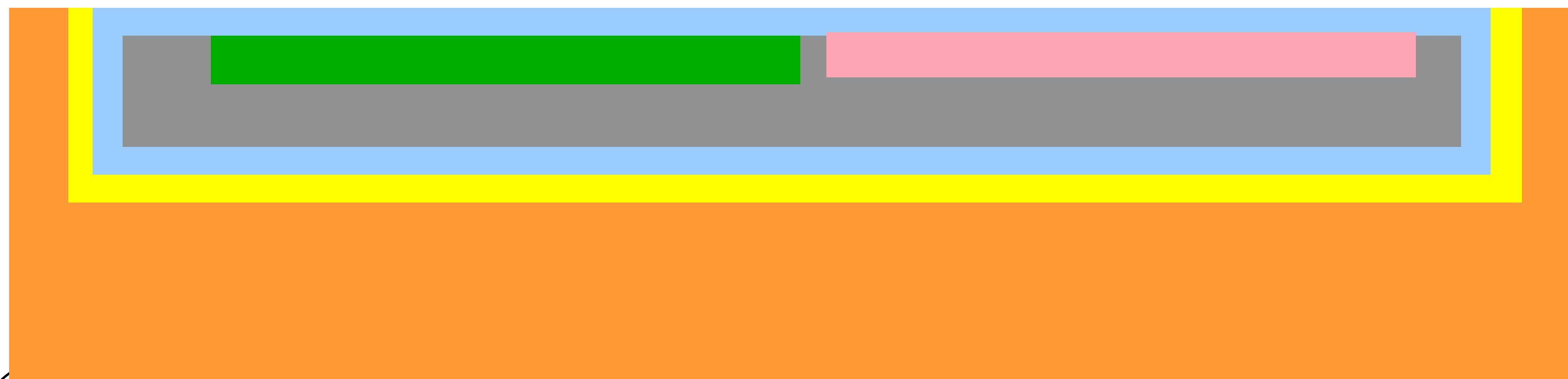
Spin Coat Back of Wafer
Hand Coat edges of Wafer



PLASMA ETCH TOOL

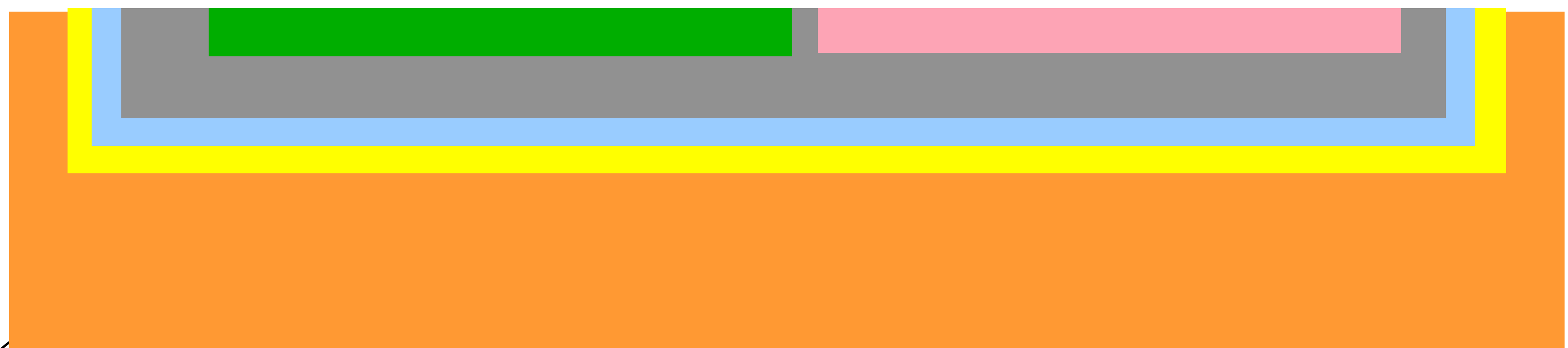
Lam 490 Etch Tool
Plasma Etch Nitride (~ 1500 Å/min)
SF6 flow = 200 sccm
Pressure= 260 mTorr
Power = 125 watts
Time = 2 min 40 sec Time Only

AFTER PLASMA ETCH OF FRONT OF WAFERS

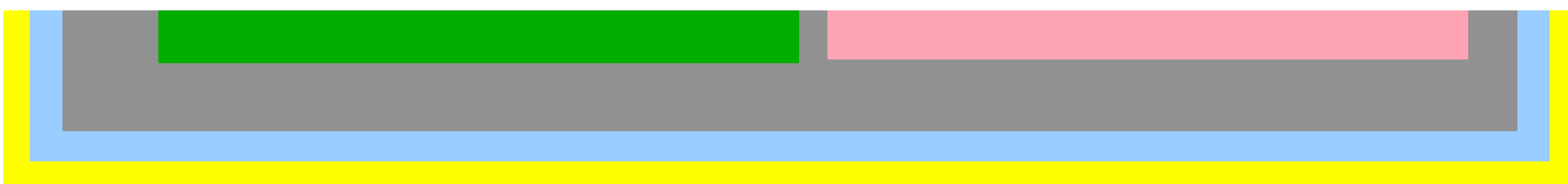


BOE ETCH OF 500Å OXIDE

Etch in 5.2:1 BOE for 1 min

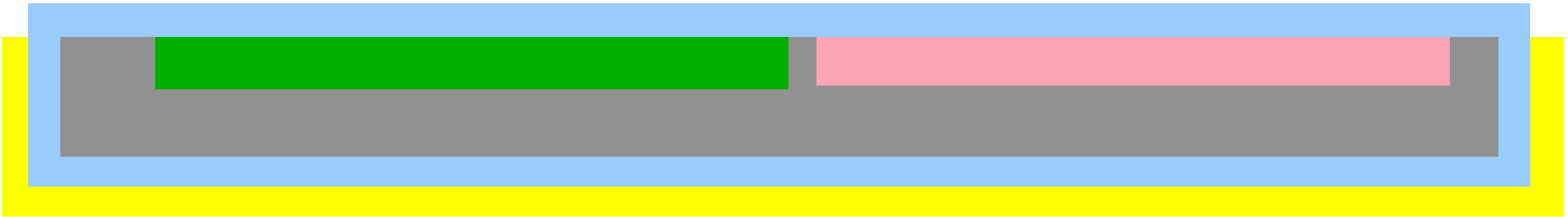


STRIP RESIST, CLEAN AND GROW 5000Å OXIDE



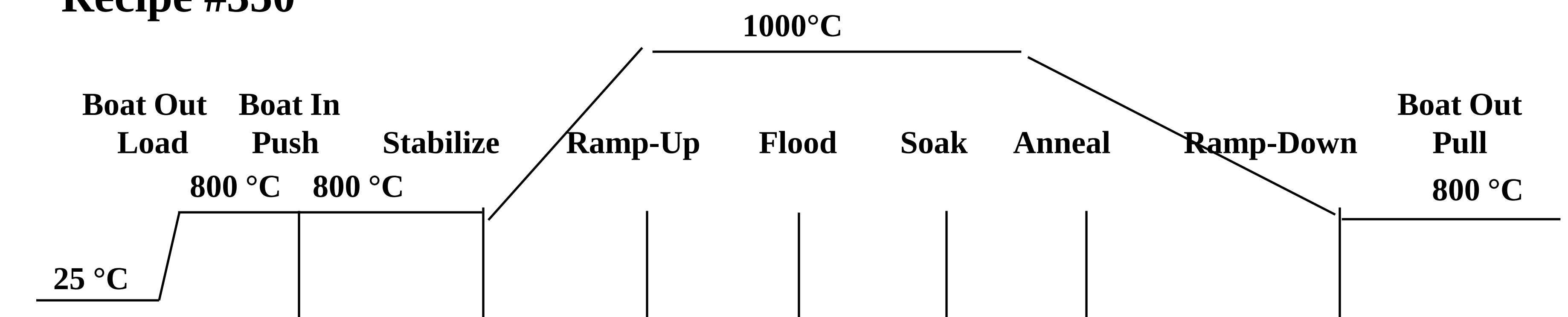
GROW 5000Å OXIDE

Masking Oxide, 5000 Å
Bruce Furnace 01, Recipe 350
1000 °C, 100 min.



BRUCE FURNACE RECIPE 350 – WET OXIDE 5,000Å

Recipe #350



Interval 0	Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7	Interval 8
Any	12 min	15 min	20 min	5 min	100 min	5 min	40 min	12 min
0 lpm	10 lpm	10 lpm	5 lpm	10 lpm	3.6/2.0 lpm	15 lpm	10 lpm	5 lpm
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 5000 Å

3RD LEVEL PHOTO - SILICON NITRIDE ETCH

The objective is to plasma etch the nitride one the back of the wafer where the diaphragms will be etched. Alignment to the front side of the wafer is critical and is accomplished as shown below

BACKSIDE ALIGNMENT

Photo 3 – Diaphragm
Coat back of wafer with Potoresist

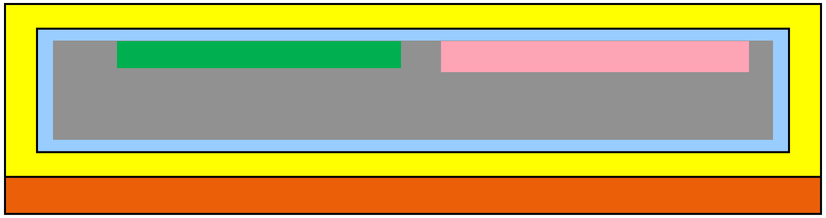


Photo 3 – Diaphragm
Align diffusion mask to the front of the wafer

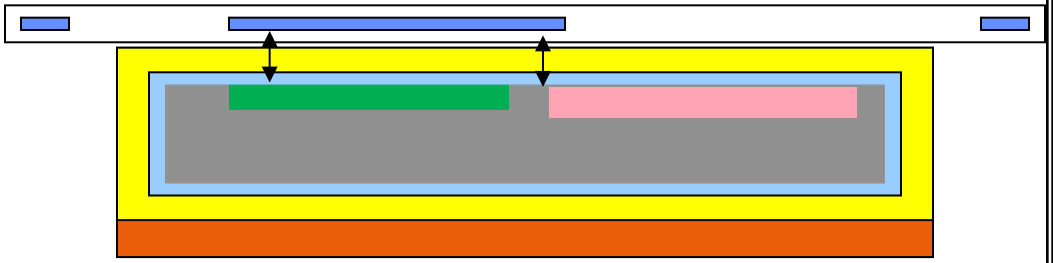
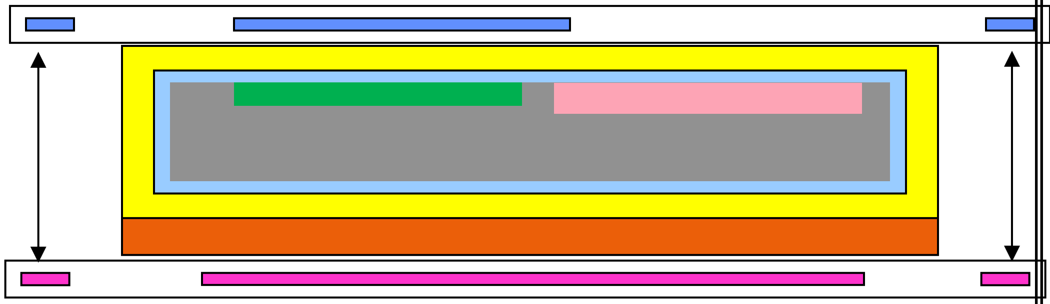


Photo 3 – Diaphragm
Align diaphragm mask to the diffusion mask



Rochester Institute of Technology
Microelectronic Engineering

CONTINUE BACK SIDE ALIGNMENT

Photo 2 – Diaphragm
Clamp, Flip and expose
20 sec exposure

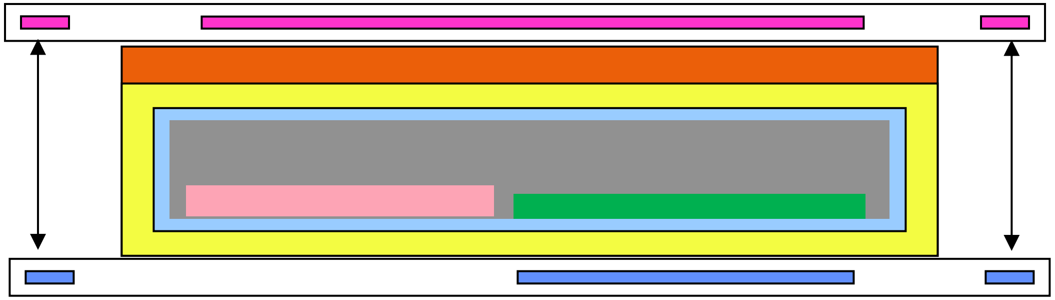


Photo 2 – Diaphragm
Develop

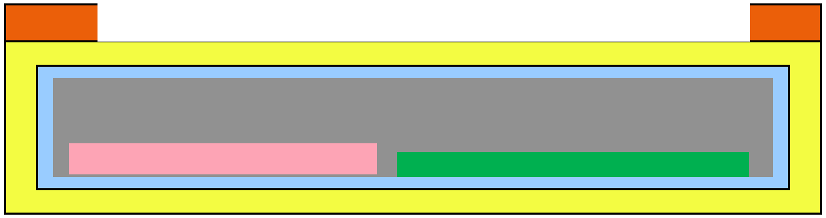
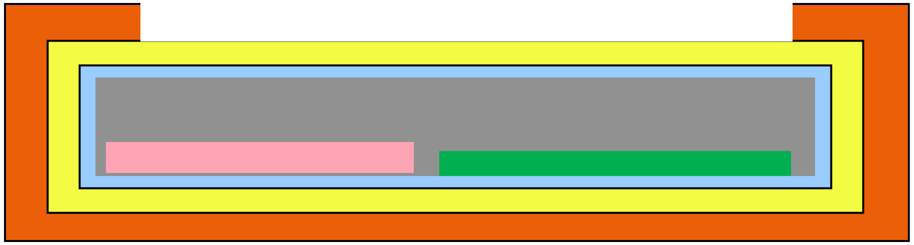
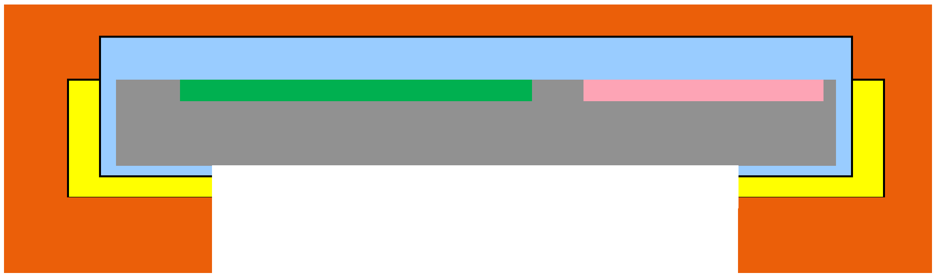


Photo 2 – Diaphragm
Coat Photo Resist on front
and Edges of the wafer



PLASMA ETCH TOOL

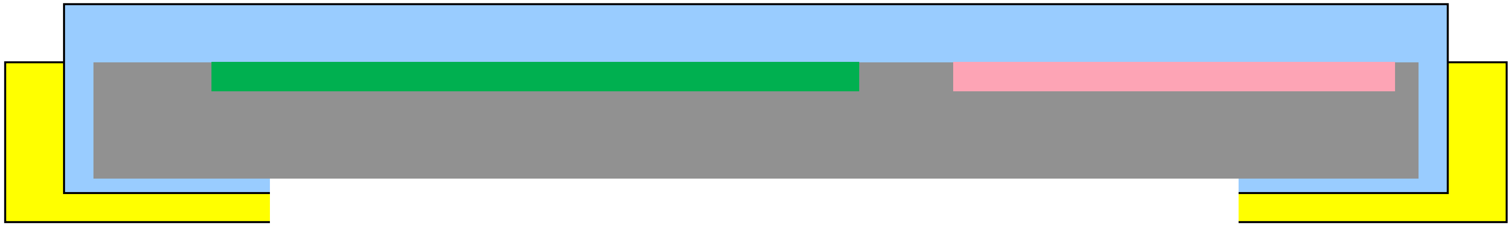


1min BOE for oxynitride
Nitride etch in LAM490 –
1 min BOE to remove pad oxide
Strip resist in solvent.

Lam 490 Etch Tool
Plasma Etch Nitride (~ 1500 Å/min)
SF6 flow = 200 sccm
Pressure= 260 mTorr
Power = 125 watts
Time = 2 min 40 sec Time Only

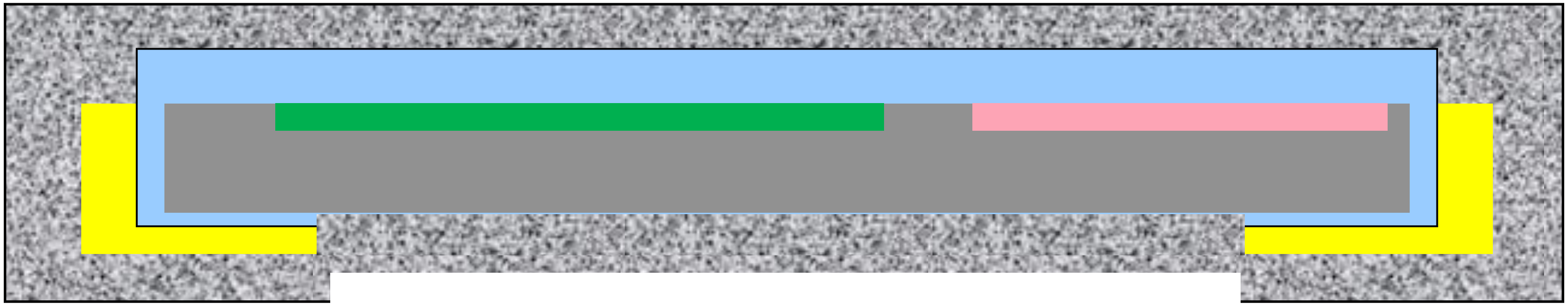
AFTER SOLVENT RESIST STRIP

LPCVD Poly deposition 6KÅ
86min Dep



DEPOSIT POLYSILICON

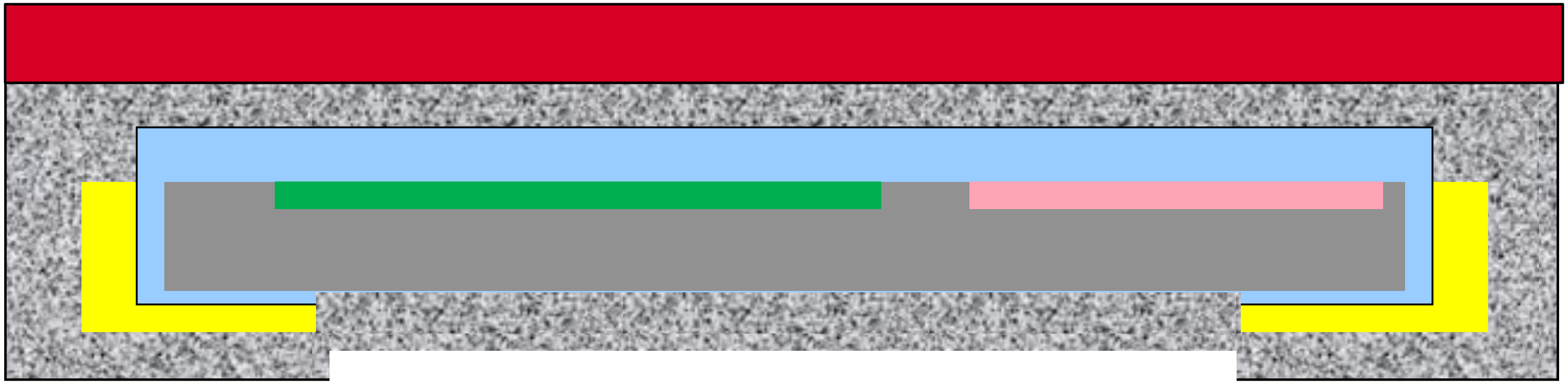
6" LPCVD Tool
6000 Å Poly Silicon
Temp = 610 °C
Pressure = 330 mTorr
Silane Flow 45%
Time = 70 min.
Include Monitor Wafer with 1000 Å Oxide



Include monitor wafer with 1000Å oxide
Record Poly Thickness

SPIN ON N+ DOPANT ON FRONT SIDE

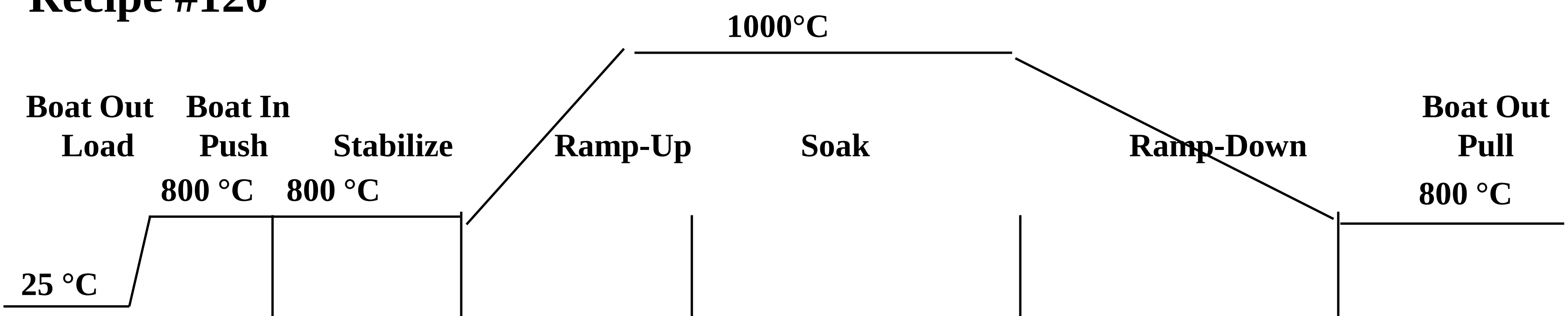
Spin on glass – N250
3,000rpm, 30 sec
20 min at 200C in Air
Diffuse with recipe 120



BRUCE FURNACE RECIPE 120- N+ POLY DOPE

Recipe #120

Verified:2-24-04



Interval 0	Interval 1	Interval 2	Interval 3	Interval 4	Interval 6	Interval 7
Any	12 min	15 min	20 min	15 min	40 min	15 min
0 lpm	10 lpm	10 lmp	5 lpm	10 lpm	10 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.

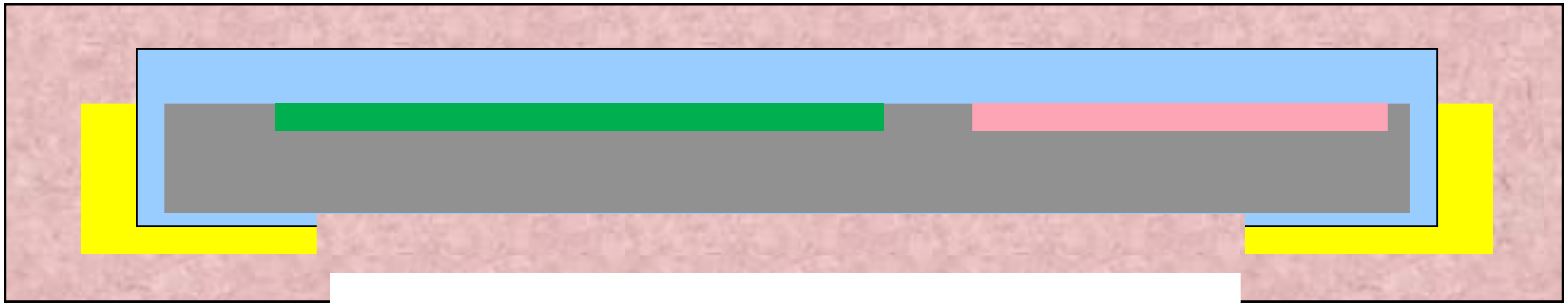
N+ Poly Doping, Thin Poly, < 1 µm, No Oxide Growth

REMOVE N+ SPIN ON GLASS

Etch all the N+ dopant glass off

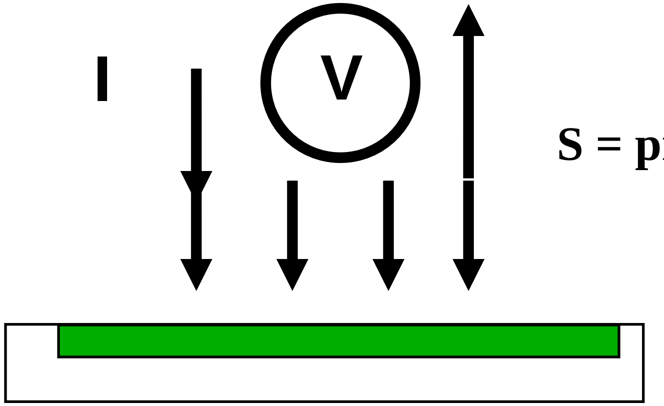
5.2:1 BOE for 6 min

4pt Probe to find sheet Rho of Poly



ETCH DOPED GLASS AND 4 PT PROBE

1) Etched Doped Glass in Buffered HF acid 3 min.
2) Rinse in DI water bath 5 min.
3) Spin Dry
4) Measure and Record Sheet Resistance



S = probe spacing

xj = Diffusion Layer Thickness

Rhos = π/ln2 x V / I = 4.532 V/I ohms/sq ,if S>xj

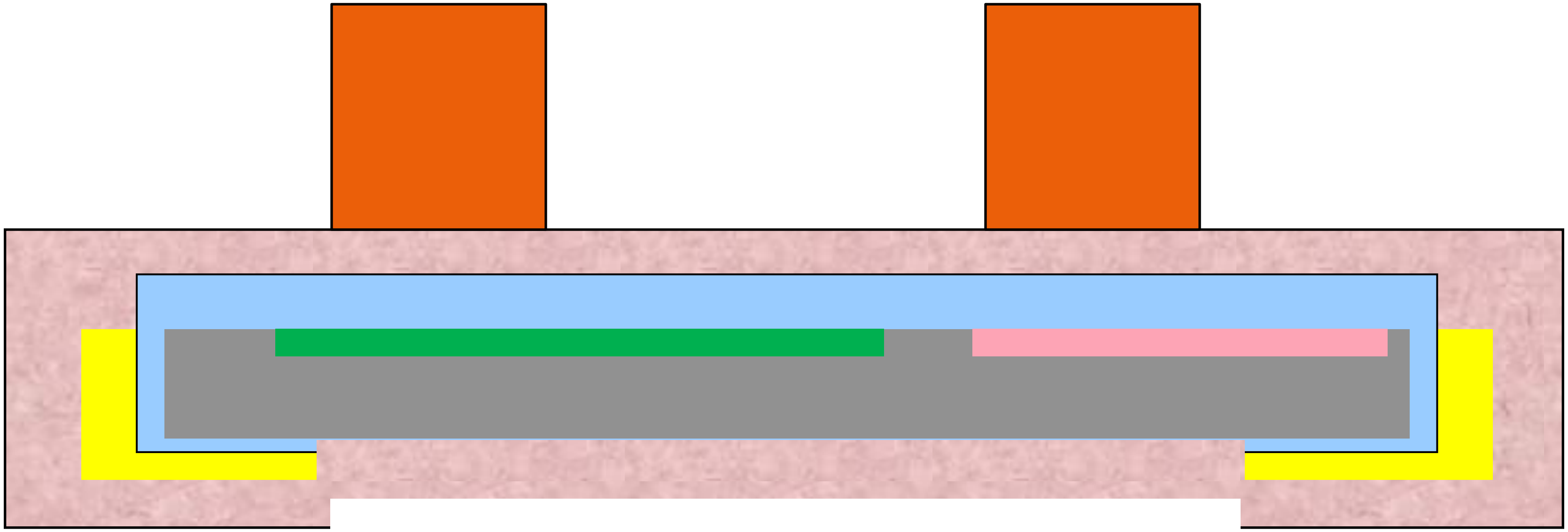
V=0.63 volts
I=0.047 amps
Rhos = 61 ohms/sq

Rochester Institute of Technology
Microelectronic Engineering

4^{th} PHOTO - POLY

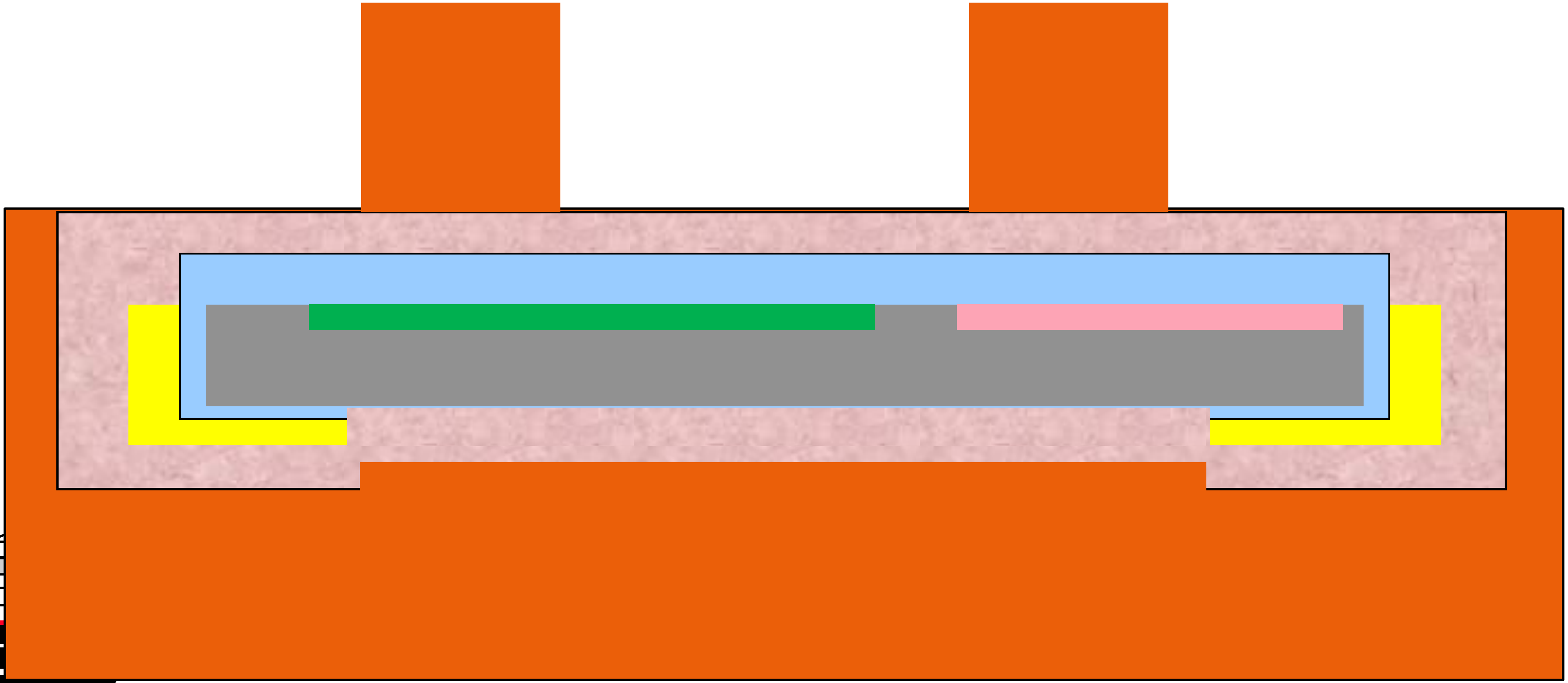
Spin coat front

Expose, Develop and Hard Bake



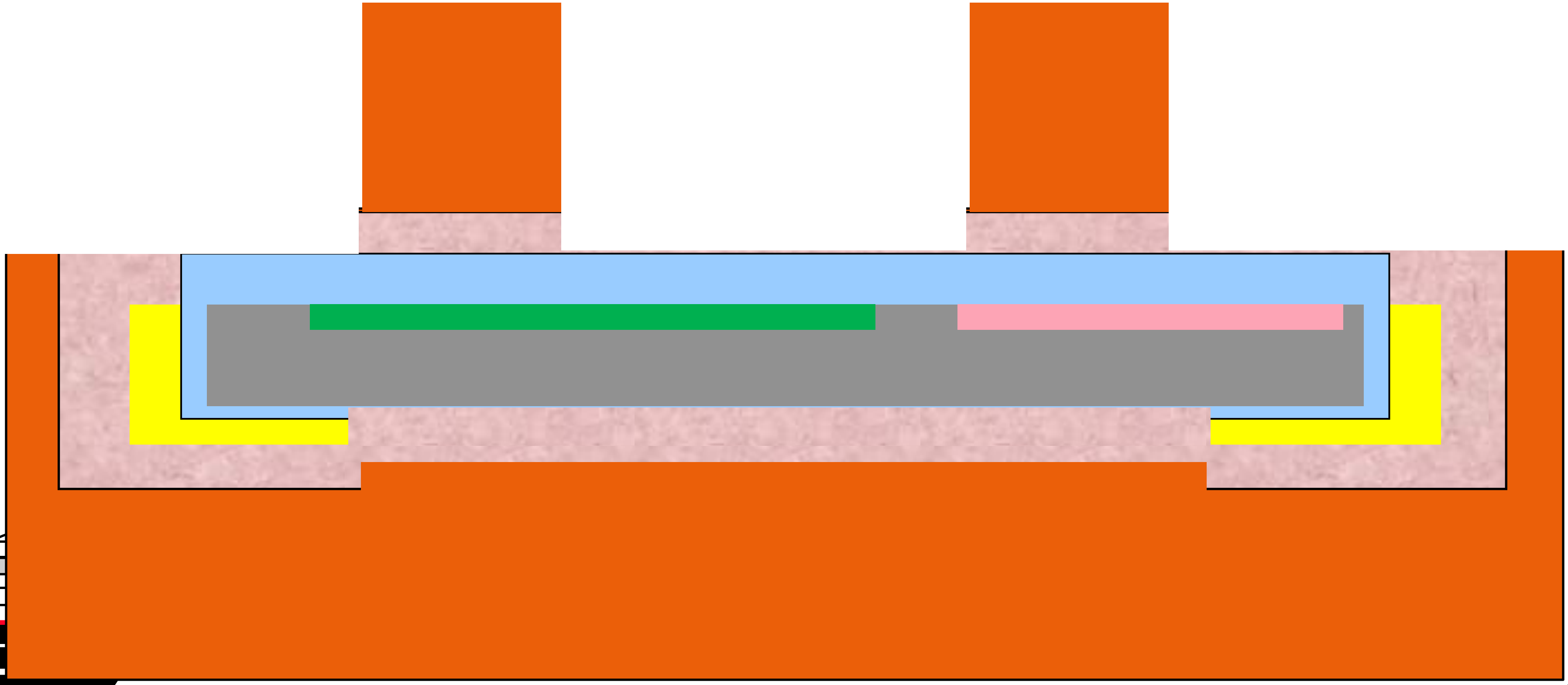
COAT WITH RESIST – BACK, AND EDGES

Spin coat back and edges, bake (do not use SVG Track)
Coat edges by hand

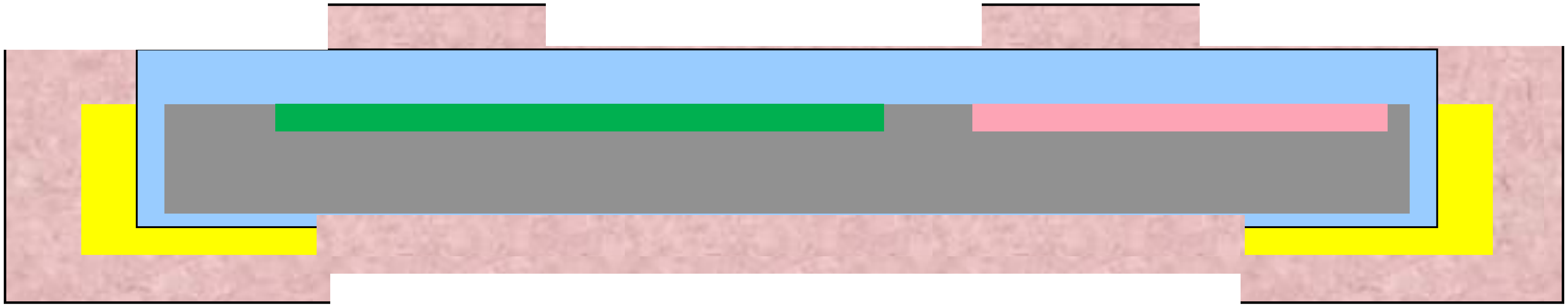


POLY ETCH USING LAM 490

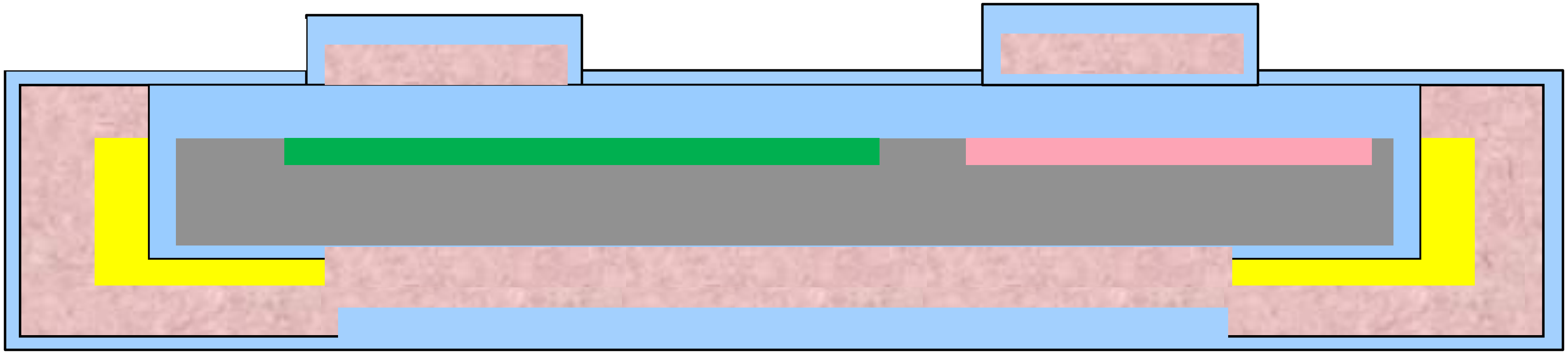
Spin coat back and edges, bake (do not use SVG Track)
Coat edges by hand



SOLVENT STRIP, RCA CLEAN

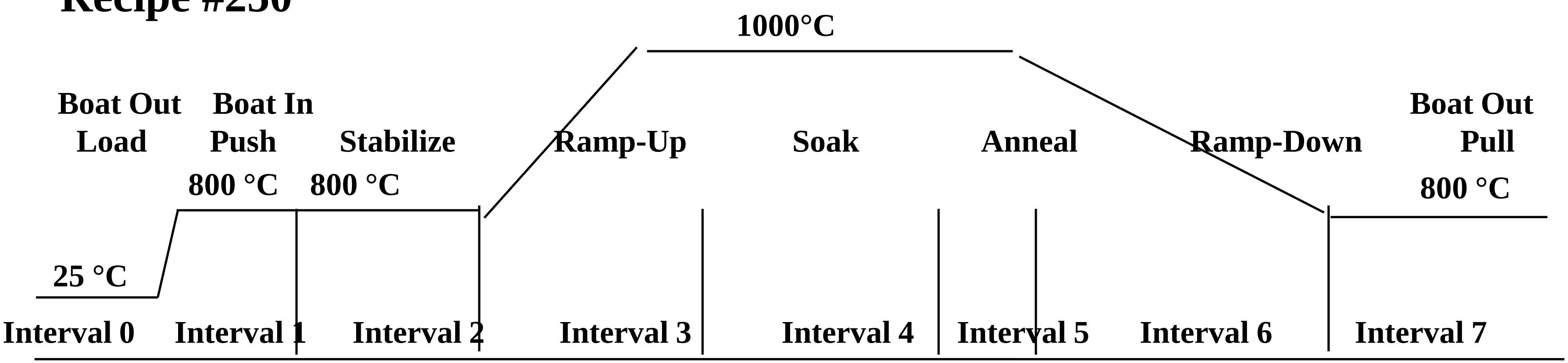


POLY REOX



BRUCE FURNACE RECIPE 250 - 500Å DRY OXIDE

Recipe #250

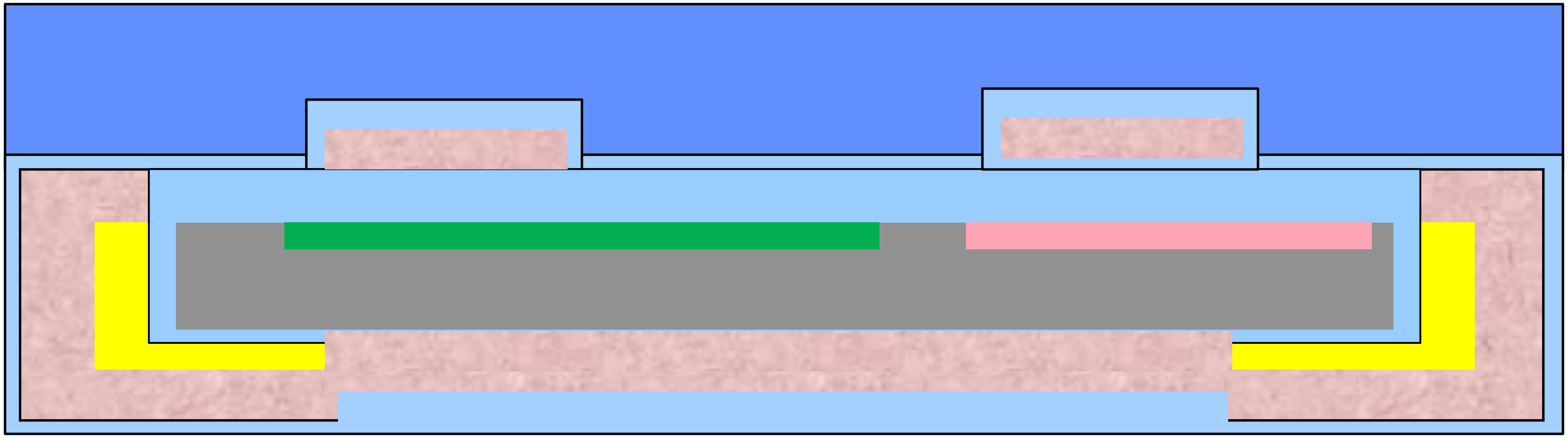


Any	12 min	15 min	20 min	56 min	5min	40 min	12 min
0 lpm	10 lpm	10 lpm	5 lpm	10 lpm	15 lpm	10 lpm	5 lpm
none	N_2	N_2	O_2	O_2	N_2	N_2	N_2

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.

Dry Oxide Growth, Target 500 Å

10,000Å PECVD TEOS



PECVD OXIDE FROM TEOS

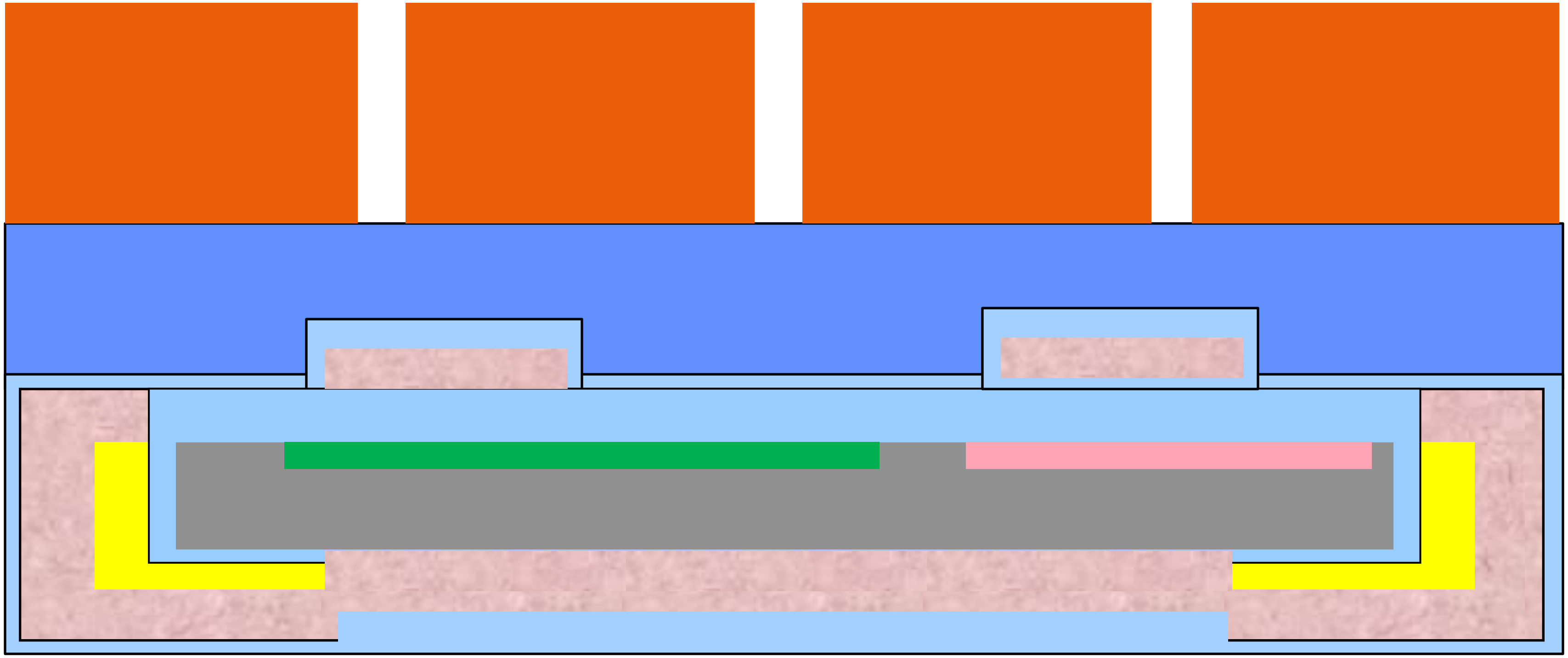
TEOS Program: (Chamber A)

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

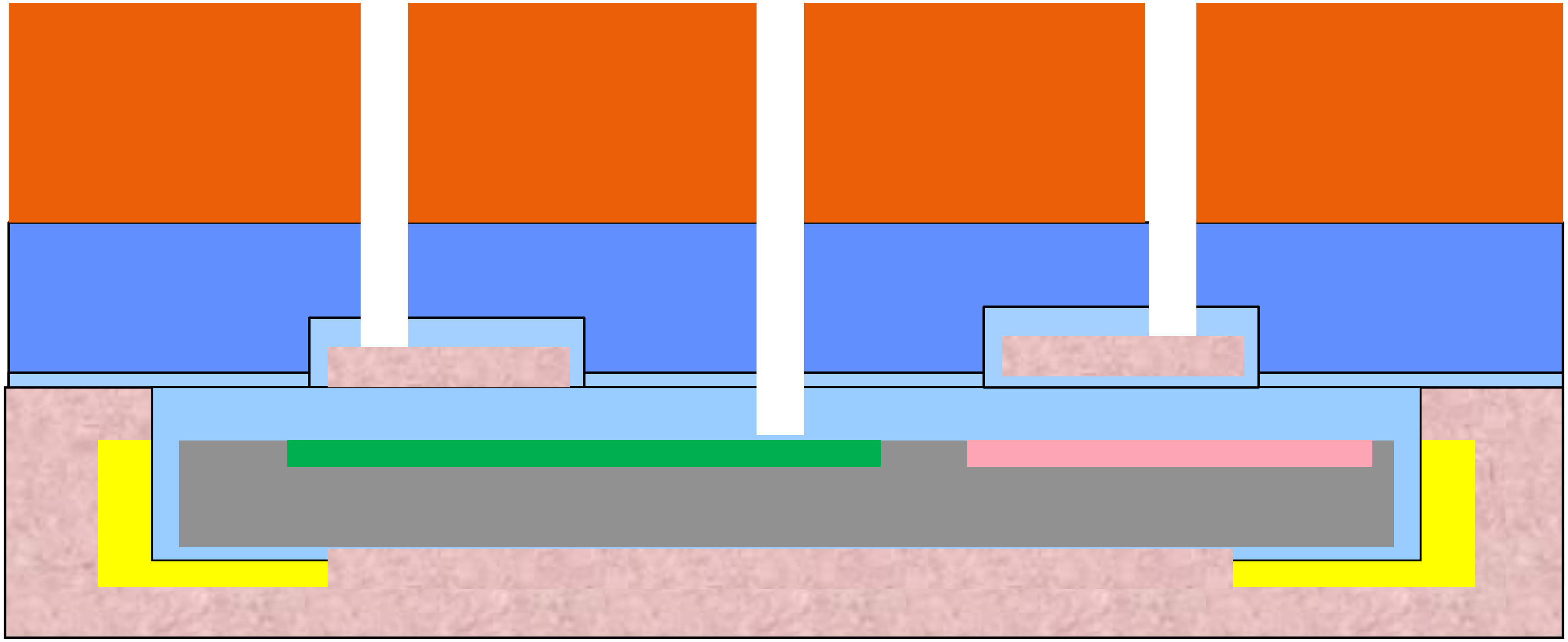
Step 2 – Deposition
- Dep Time = 55 sec (5000 Å)
- Pressure = 9 Torr
- Susceptor Temperature= 390 C
- Susceptor Spacing= 220 mils
- RF Power = 205 watts
- TEOS Flow = 400 scc
- O2 Flow = 285 scc

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

5TH LEVEL PHOTO – CONTACT CUTS

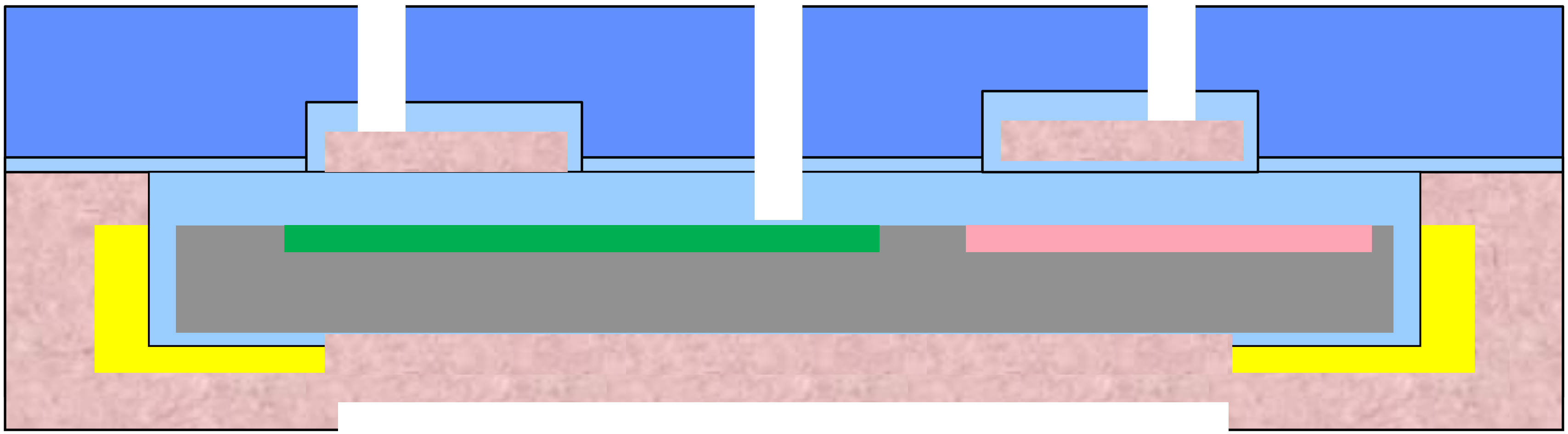


ETCH CONTACTS



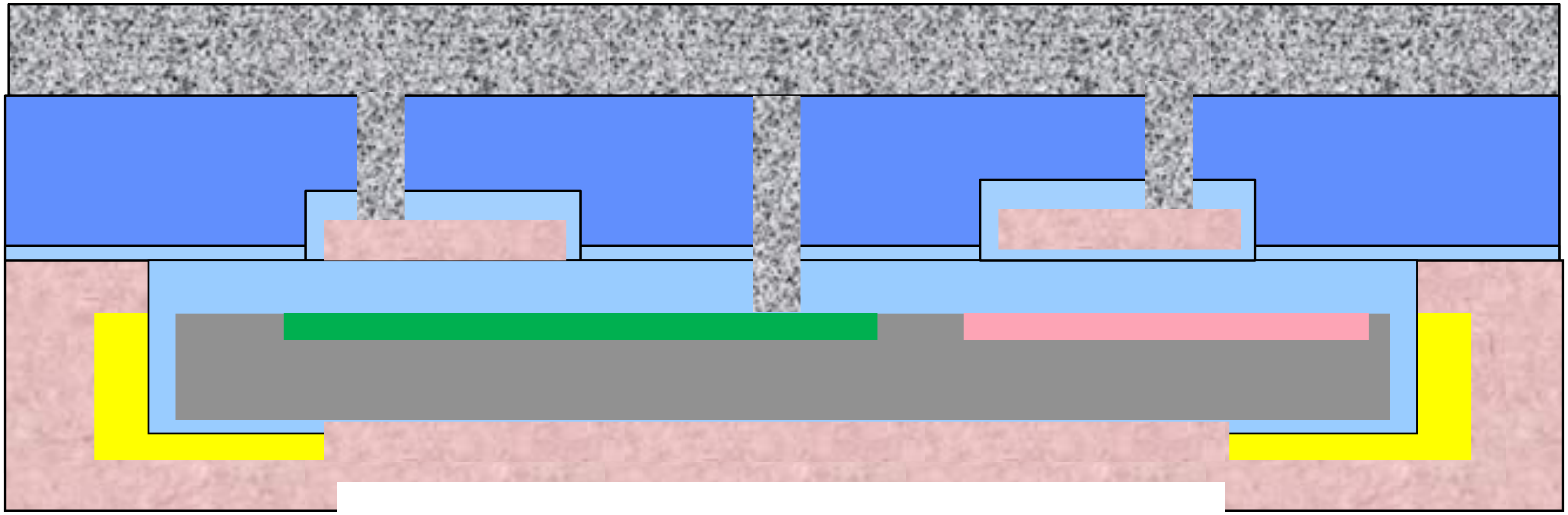
Contact cut etch
5.2:1 BOE – 10min
LTO etch rate >2KÅ/min
Thermal ox ~1100Å/min

STRIP RESIST, RCA CLEAN



RCA Clean with extra HF dip at end

SPUTTER ALUMINUM

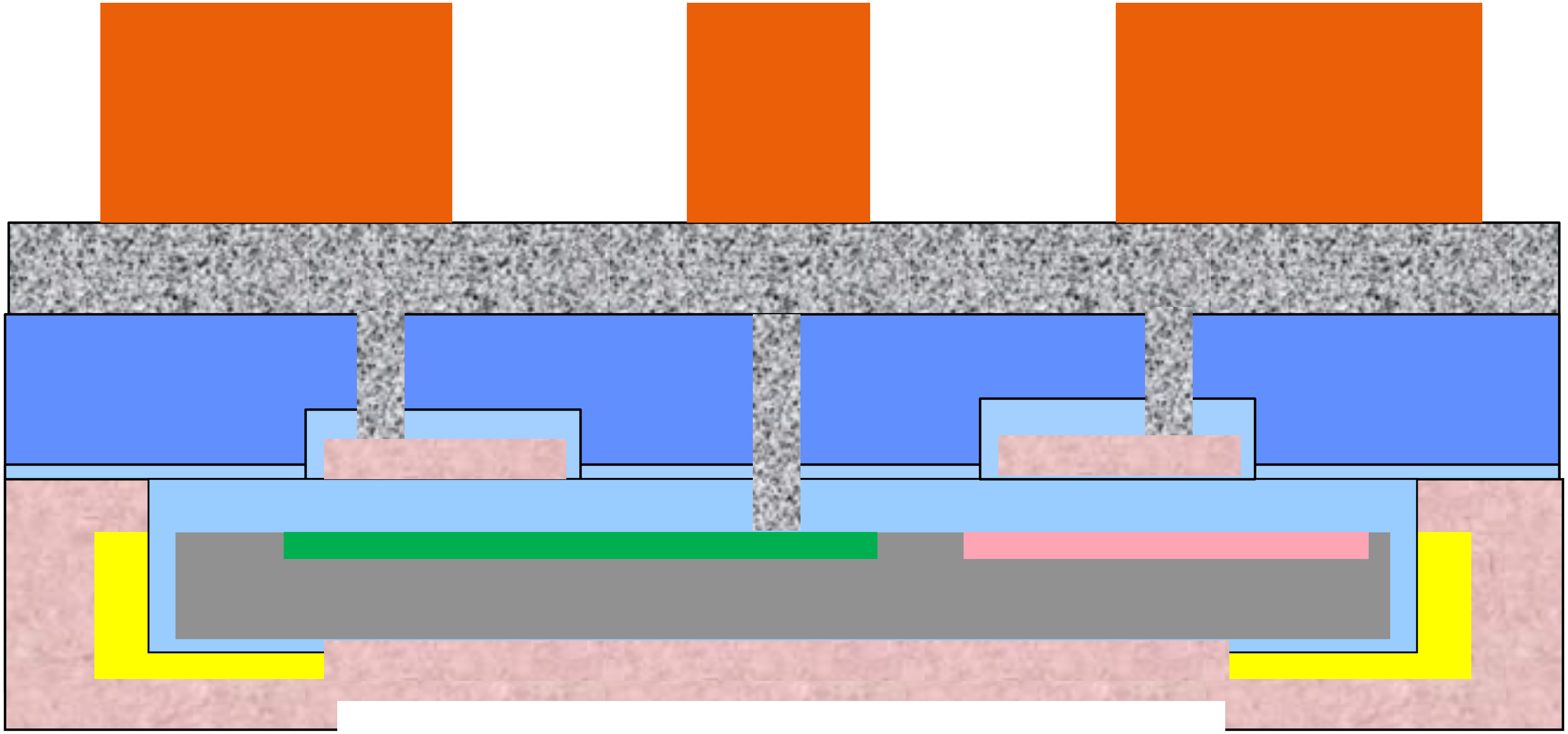


SPUTTER ALUMINUM

20 min Bake at 300 C
during pump down
Base Pressure 2E-5
2000 watts
5 mTorr Argon
5 min presputter
33 min sputter
Al/1%Si
Thickness ~1.0 µm

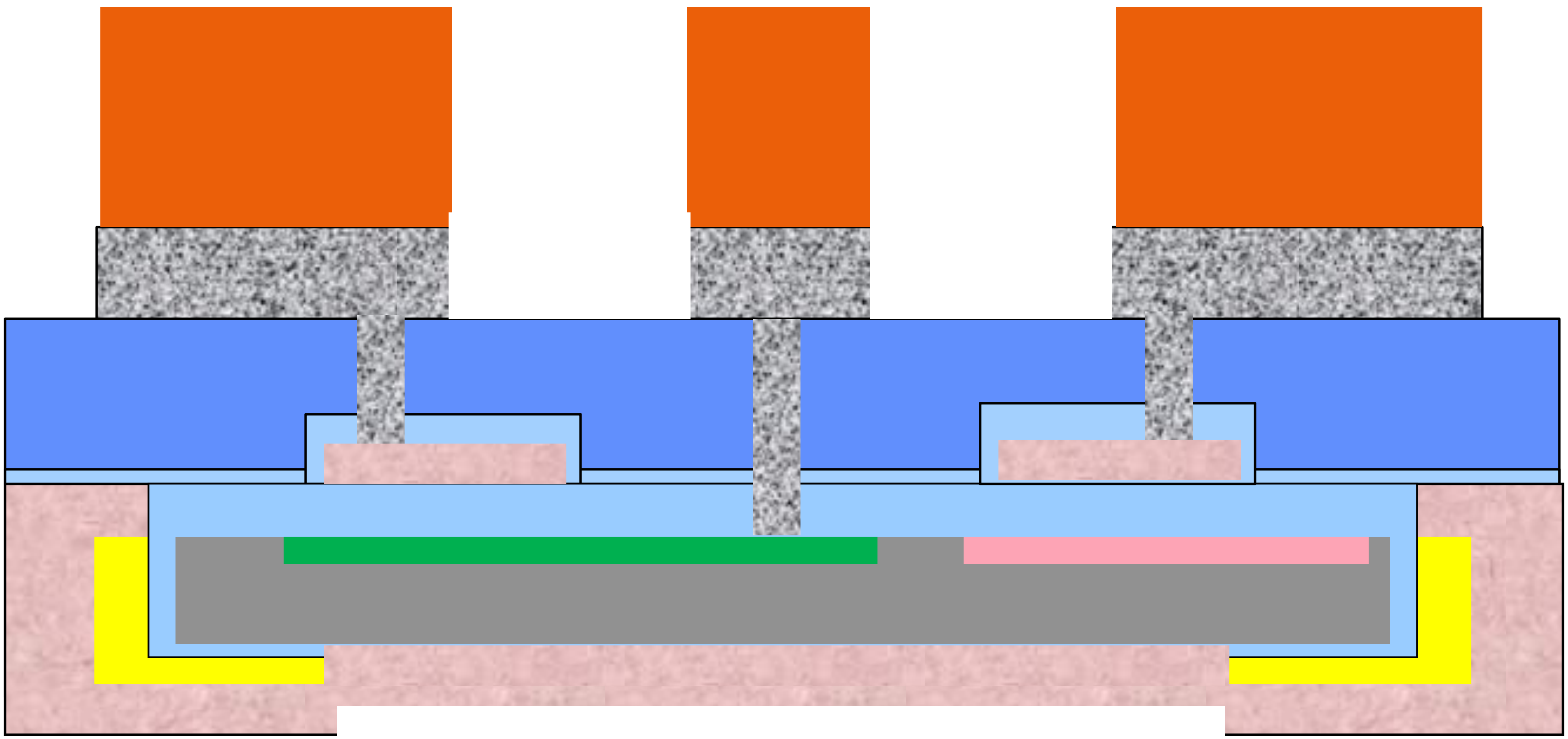
CVC 601 Sputter Tool

6TH LEVEL PHOTO - METAL



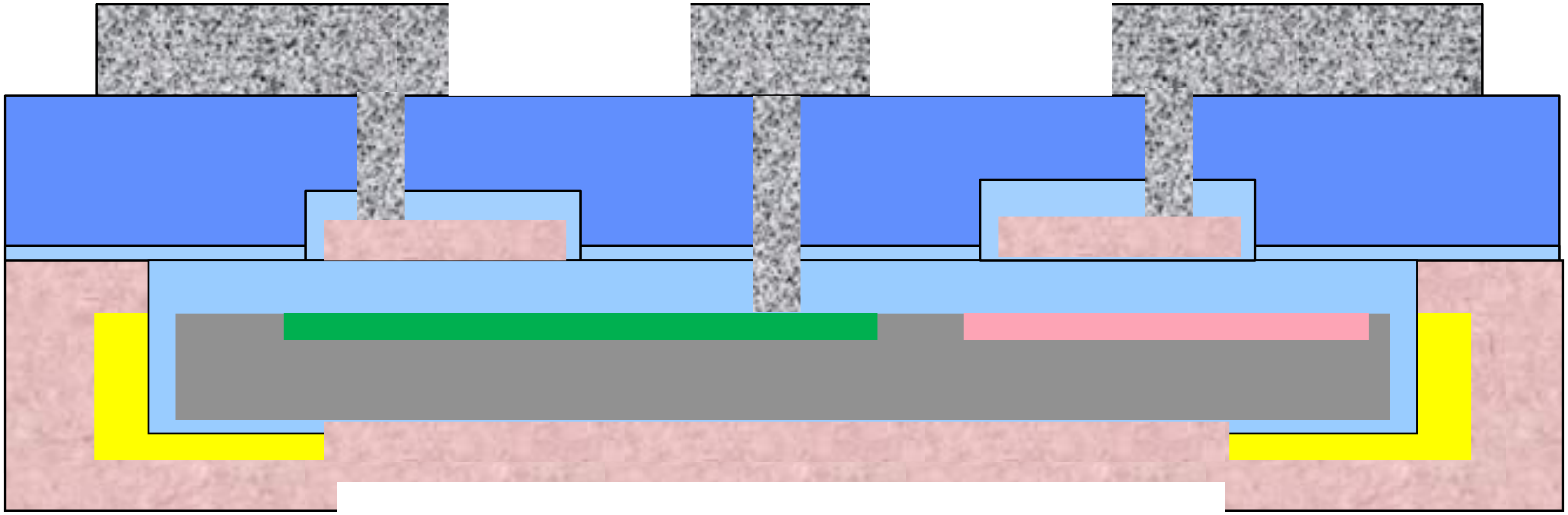
Reduce Exposure to 15seconds

METAL ETCH

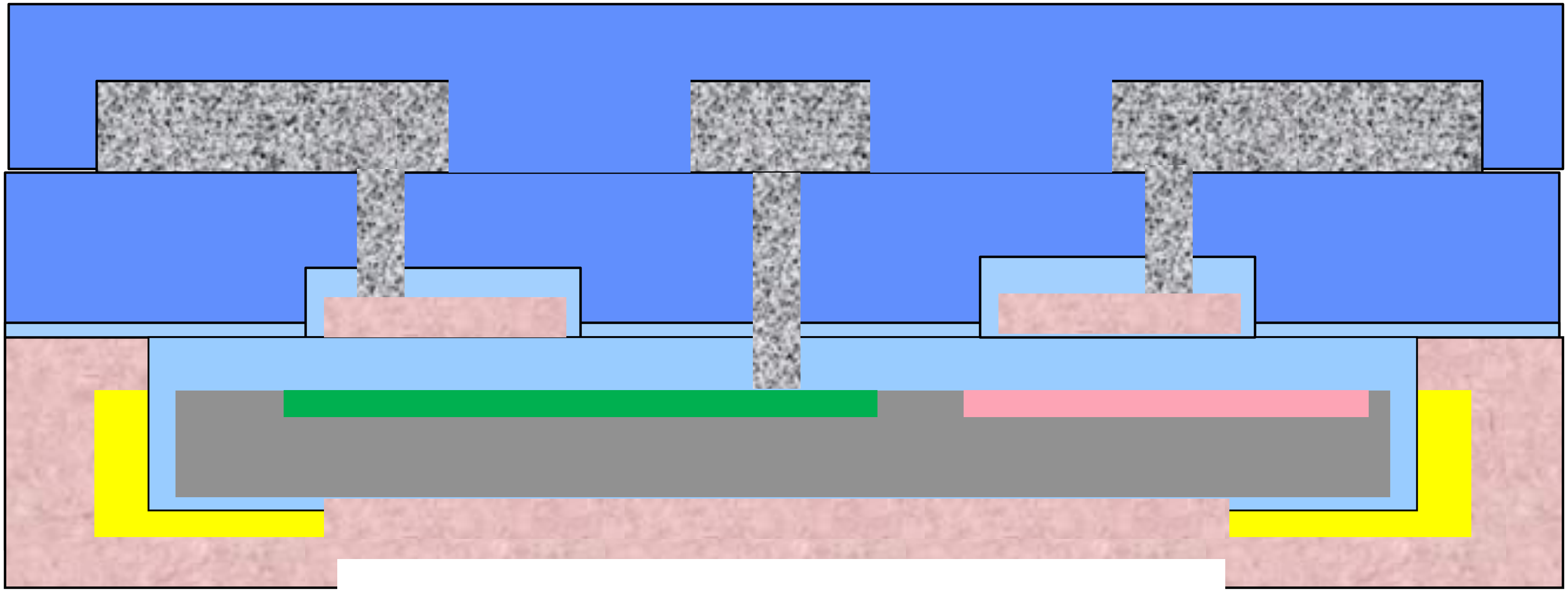


Visual End Point ~ 4 min.
Inspect using microscope

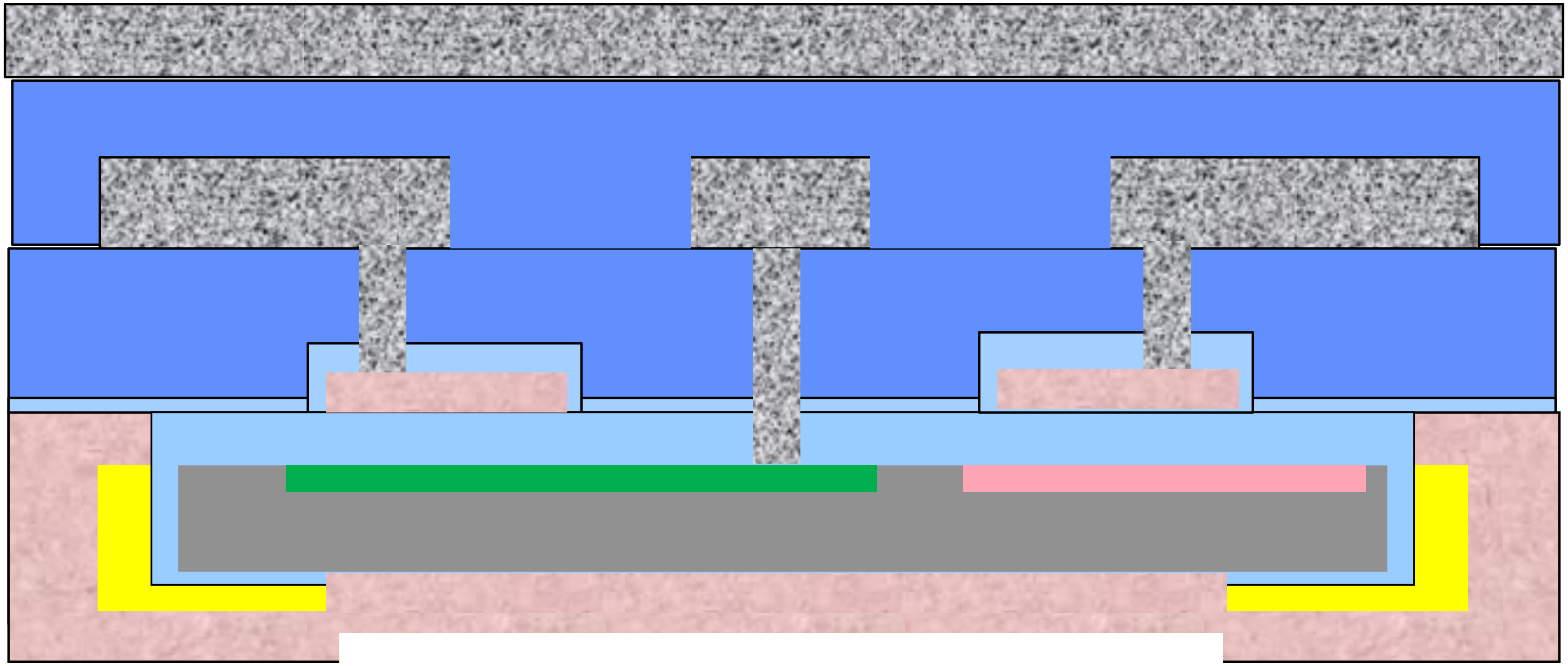
SOLVENT STRIP RESIST



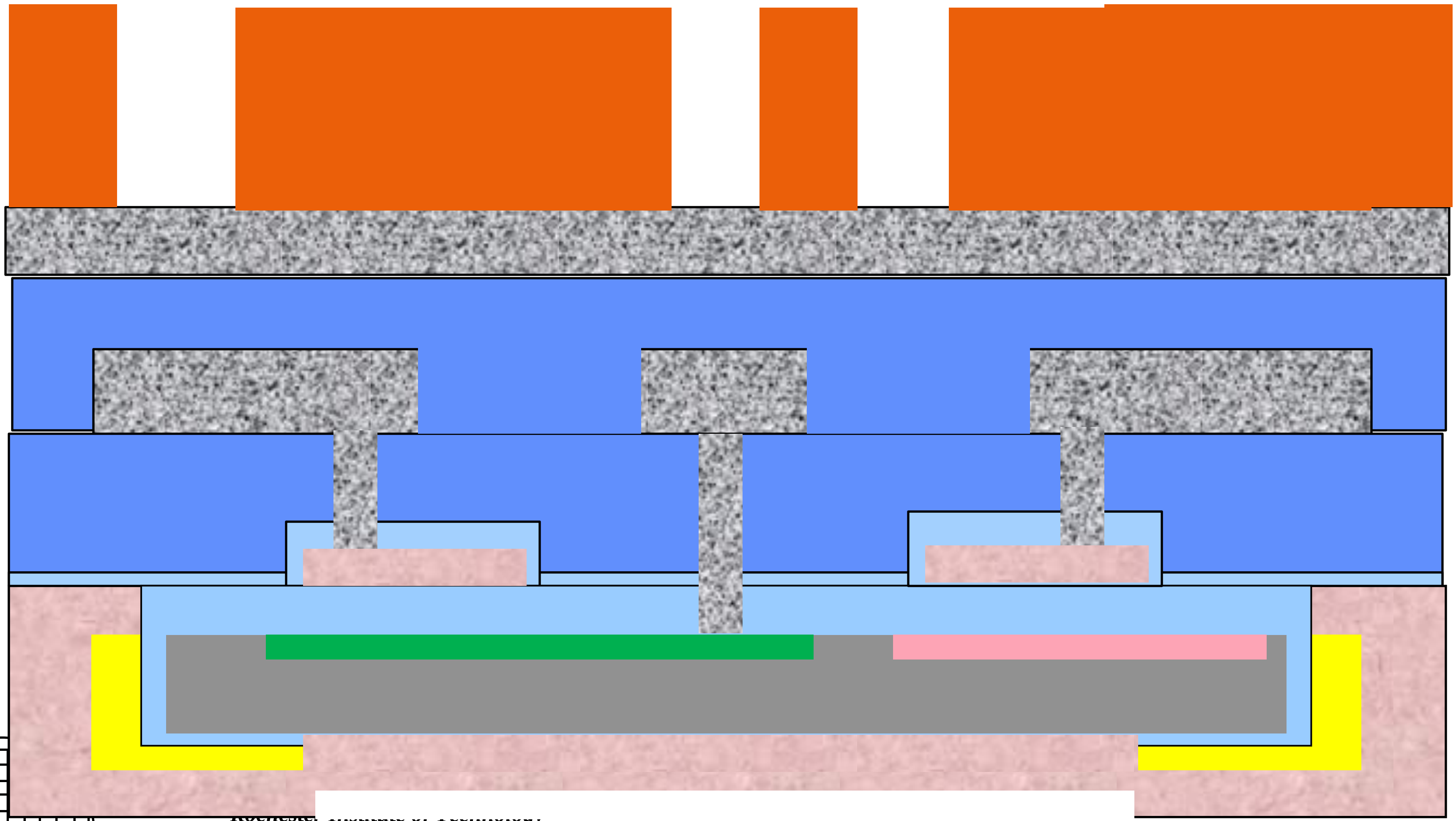
INTER LEVEL OXIDE - 8000Å TEOS



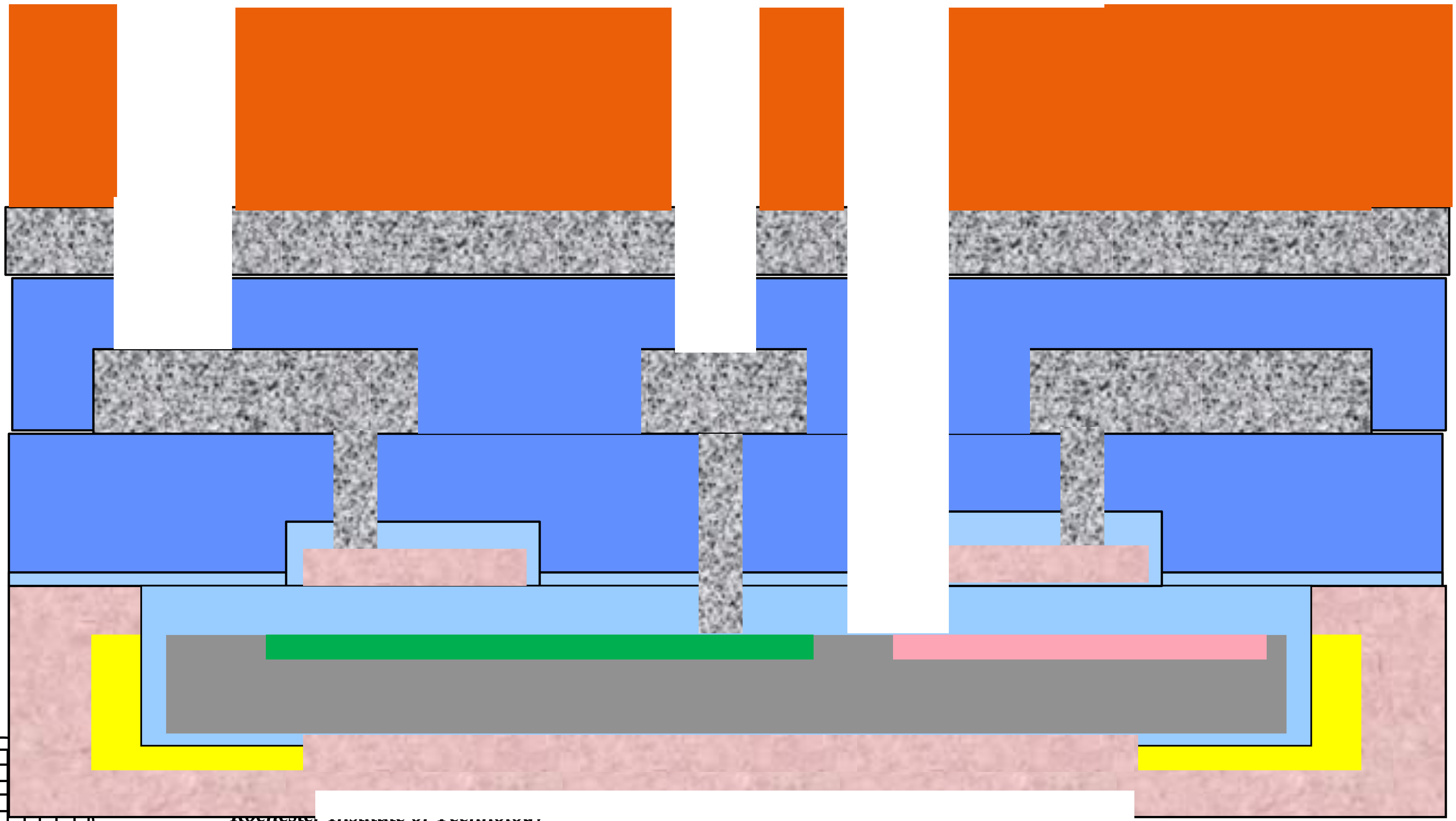
TOP METAL LAYER – 7500 Å



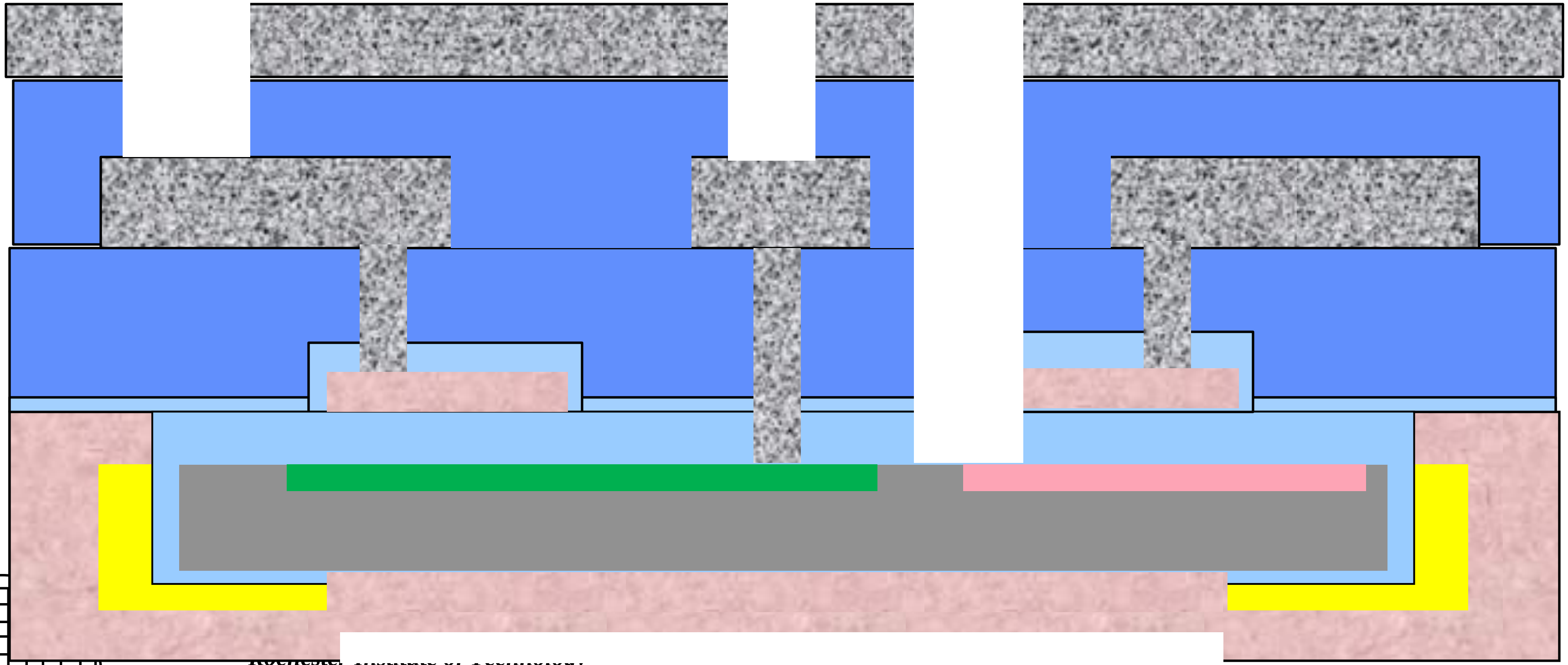
7TH LEVEL PHOTO – TOP HOLE



TOP METAL ETCH AND ILD ETCH

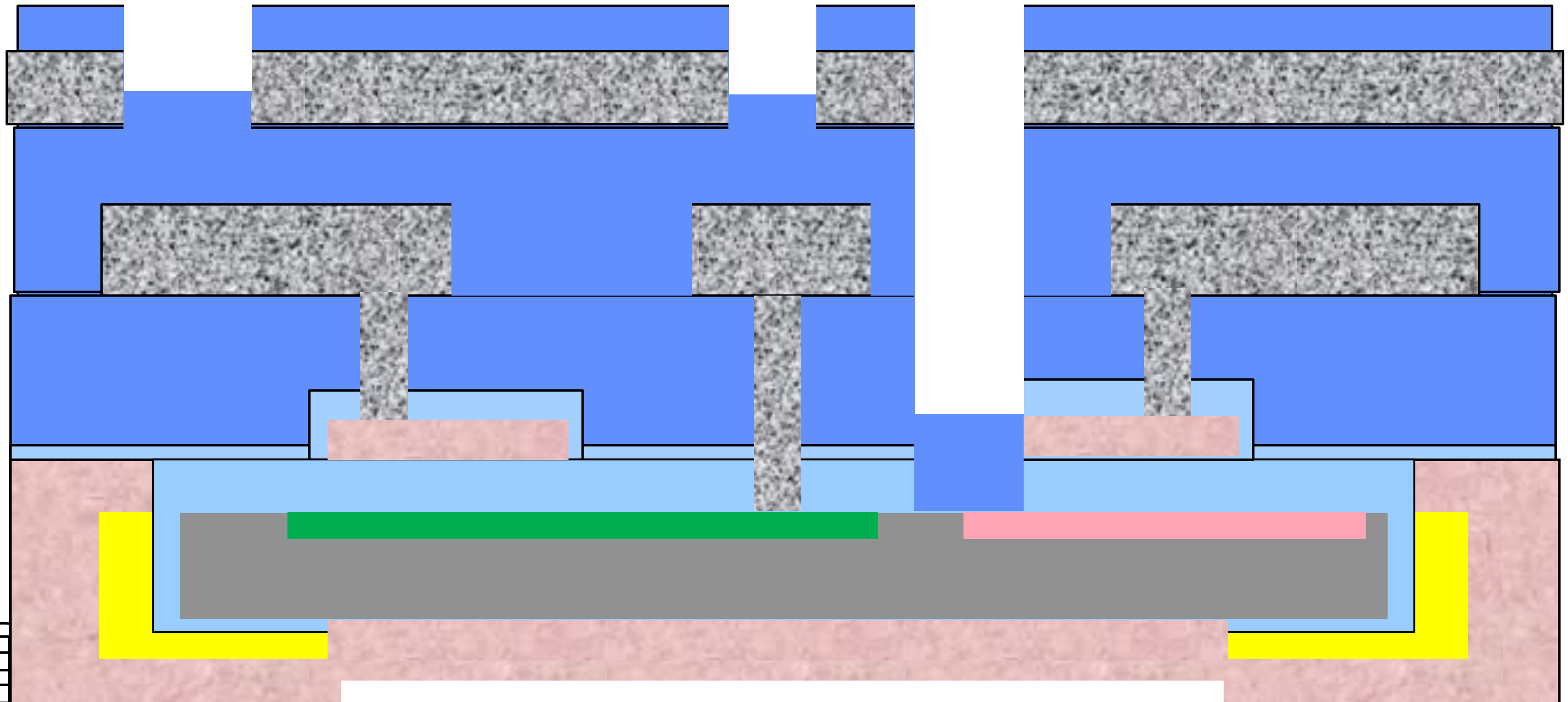


REMOVE RESIST

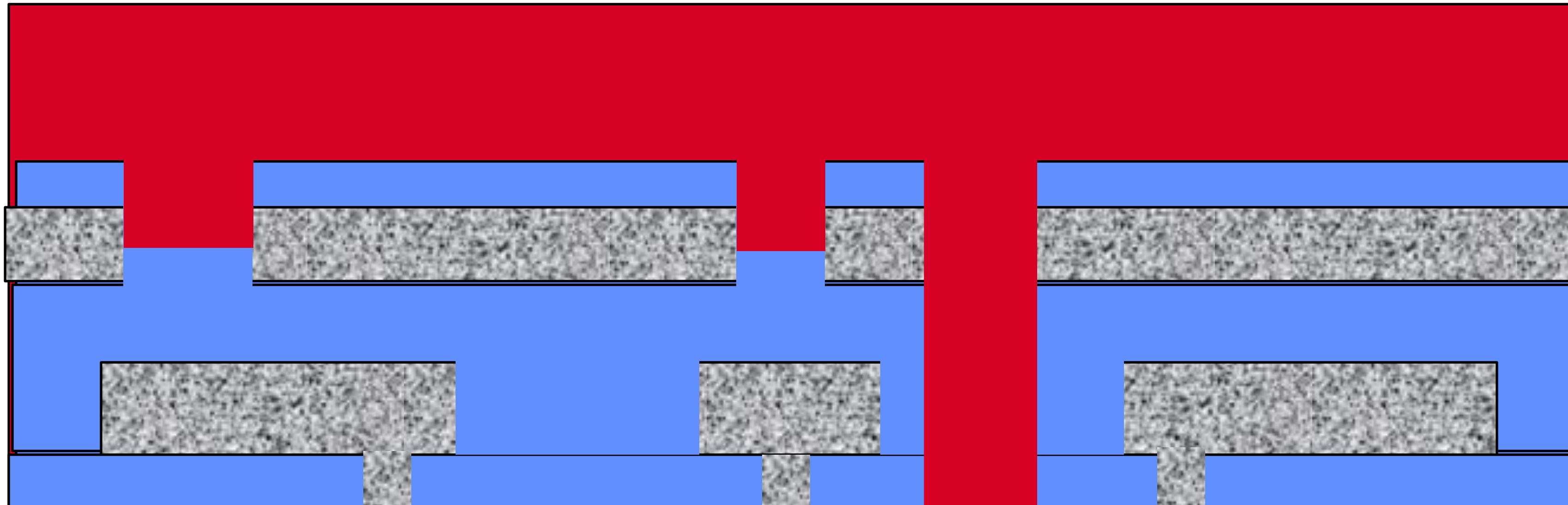


Rochester Institute of Technology
Microelectronic Engineering

PROTEK ADHESION LAYER OF TEOS

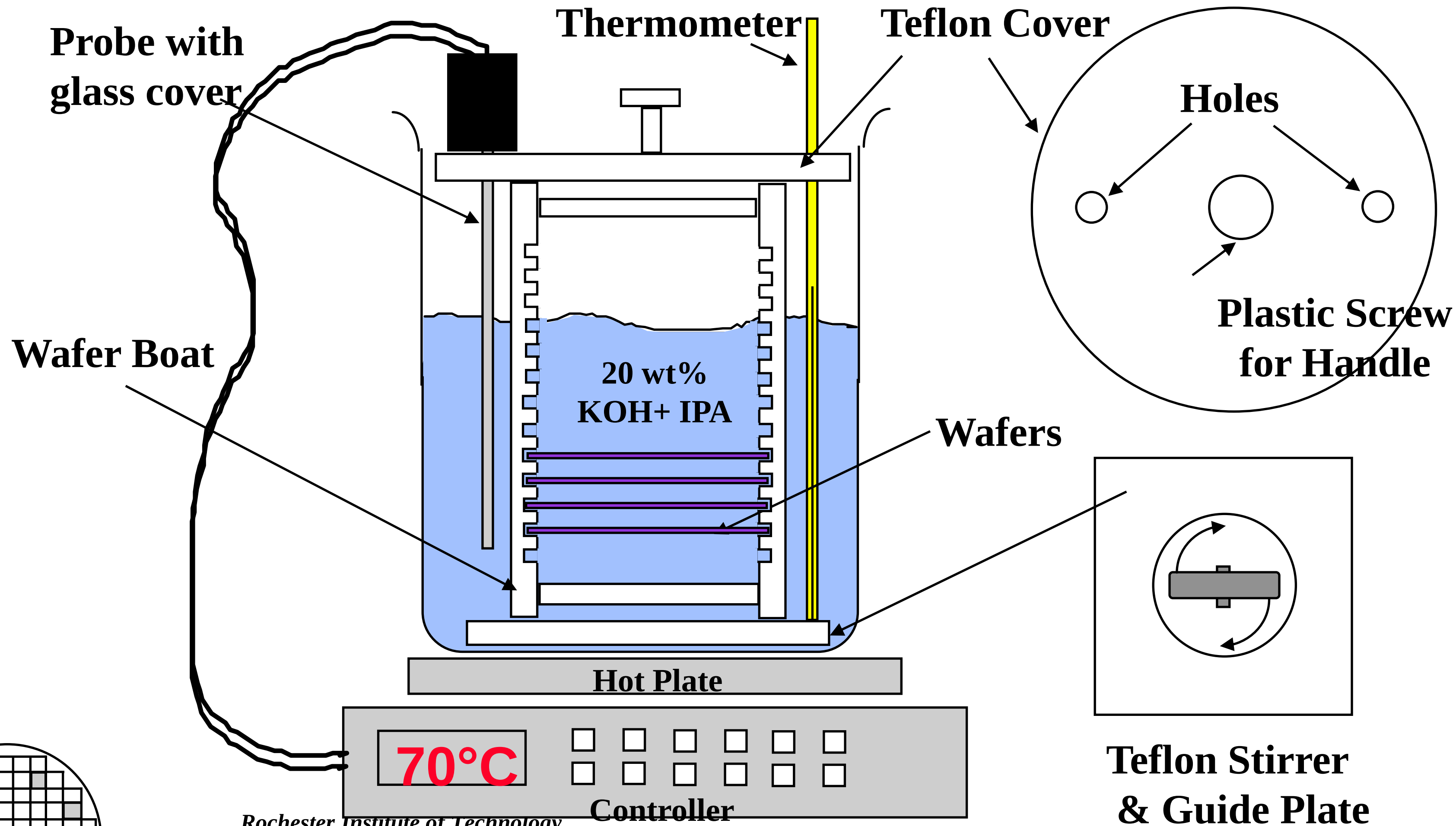


PROTEK LAYER

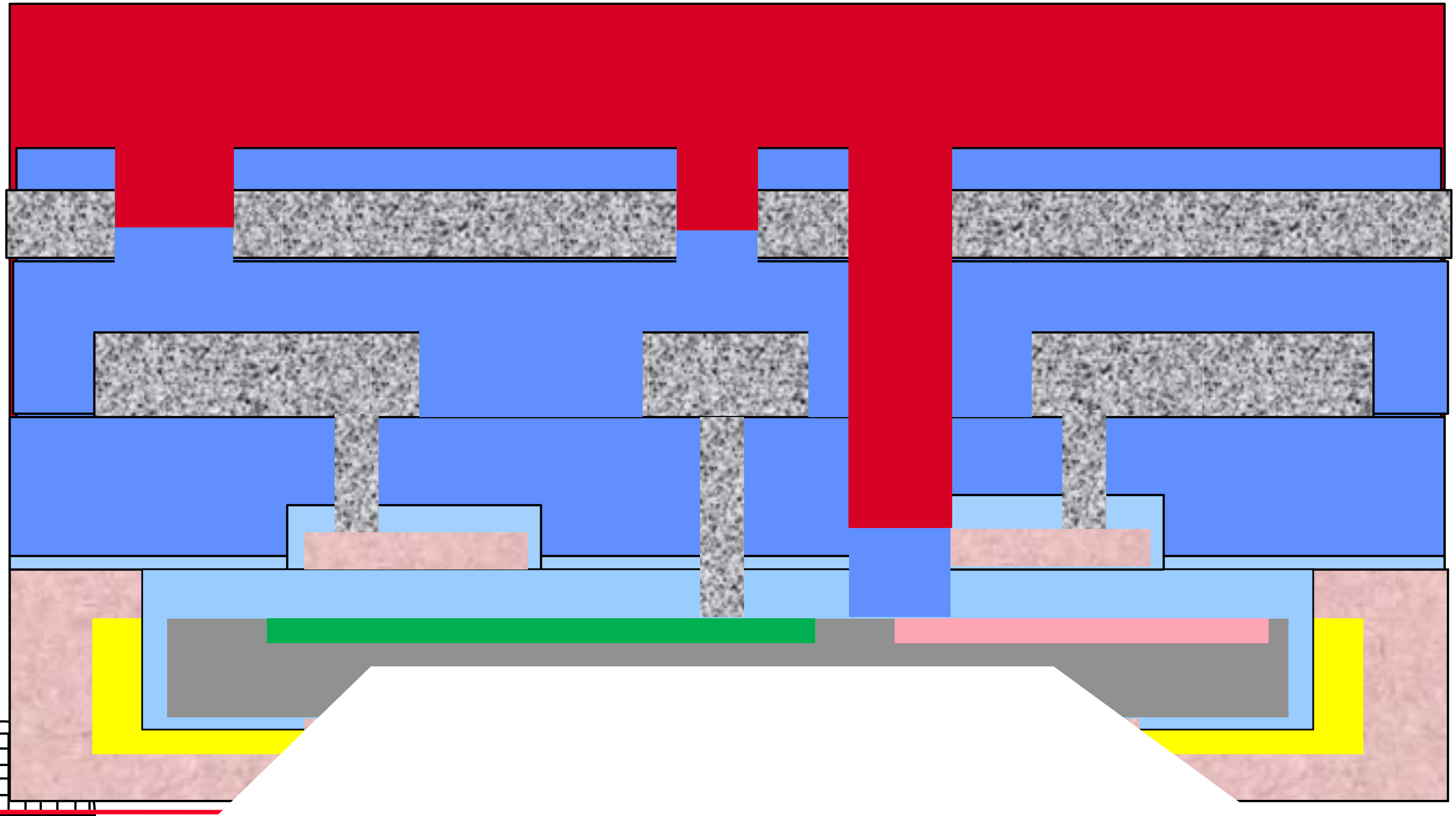


Spin on primer adhesion promoter (1500 rpm, 60sec).
Bake at 130C for 60sec.
Spin on ProTEK (1500 rpm, 90sec). Bake on hot plate 130C for 120sec, oven bake at 200C for 30min.

ETCH WAFERS IN KOH

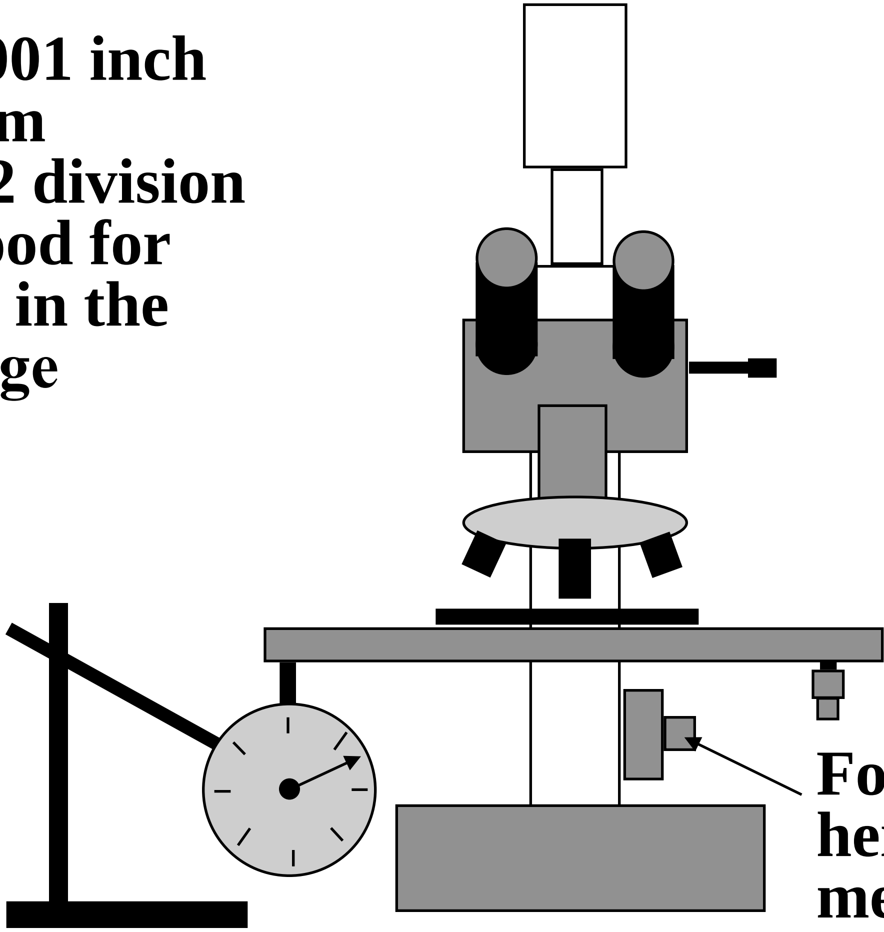


KOH ETCH BACK SIDE OF WAFER



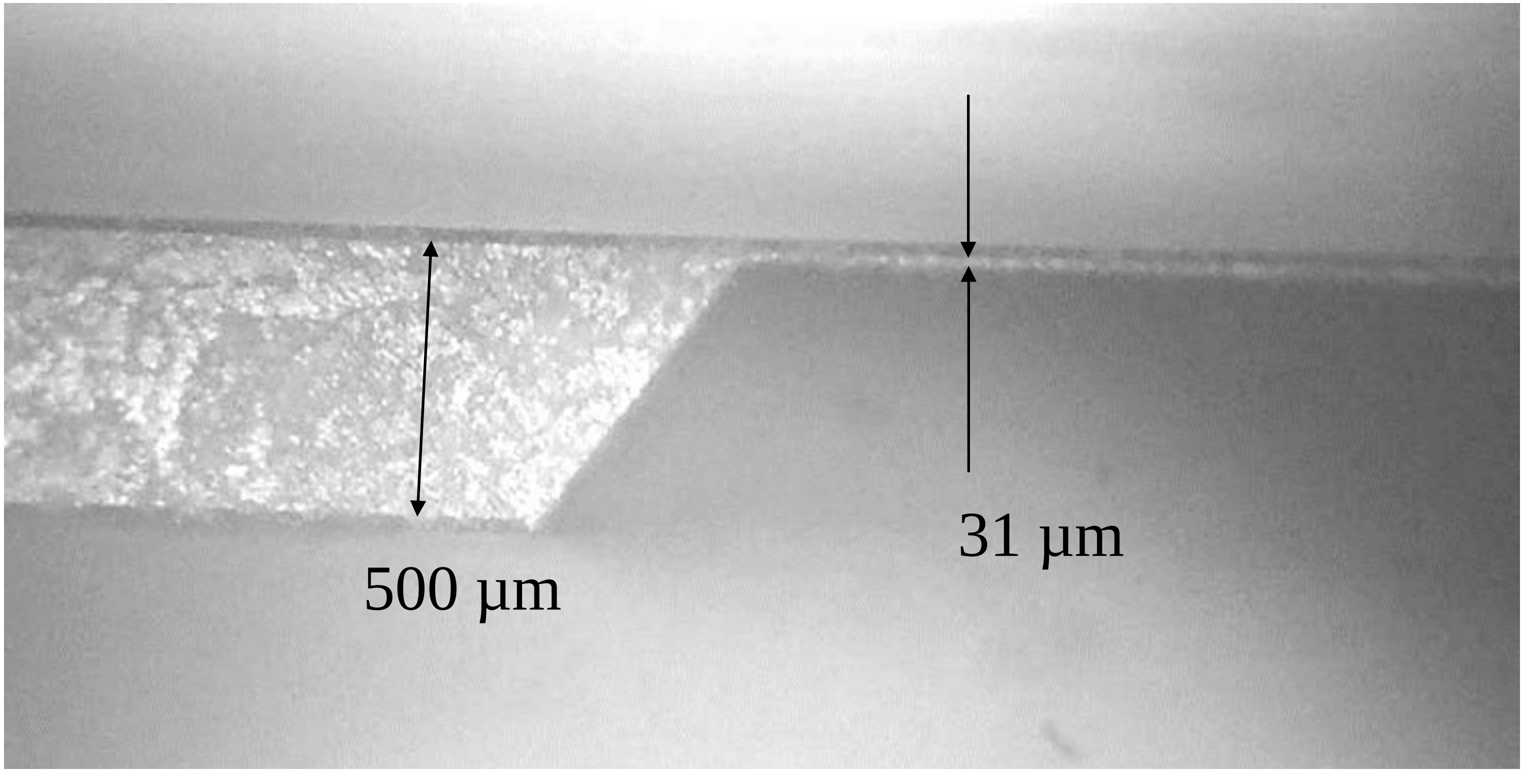
HEIGHT MEASUREMENT USING OPTICAL MICROSCOPE

Dial divisions are 0.001 inch units equal to 25.4 µm accuracy is about 1/2 division or 12.5 µm, this is good for measuring thickness in the 100's of microns range



Focus and height measurement each division is 1 µm

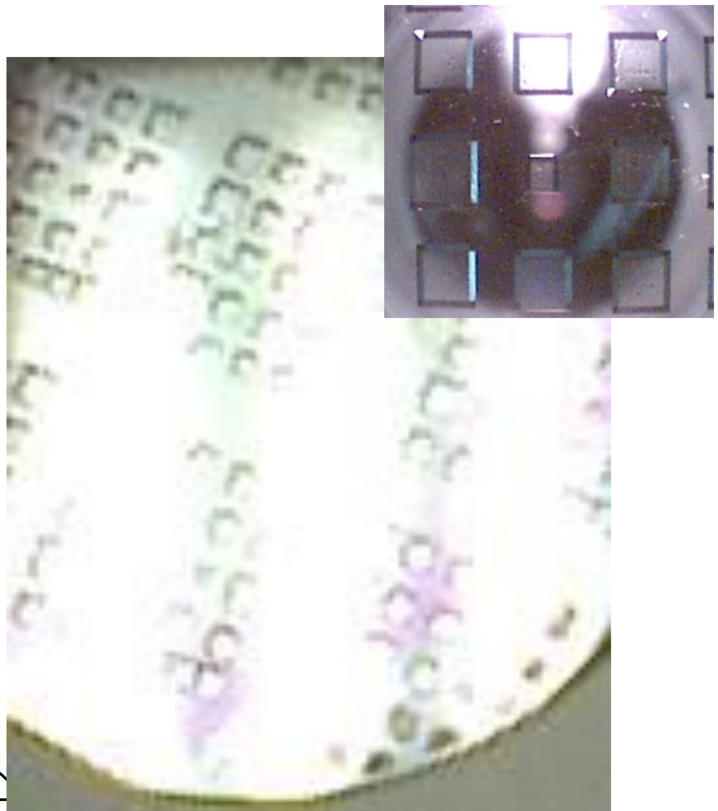
HEIGHT MEASUREMENT USING OPTICAL MICROSCOPE



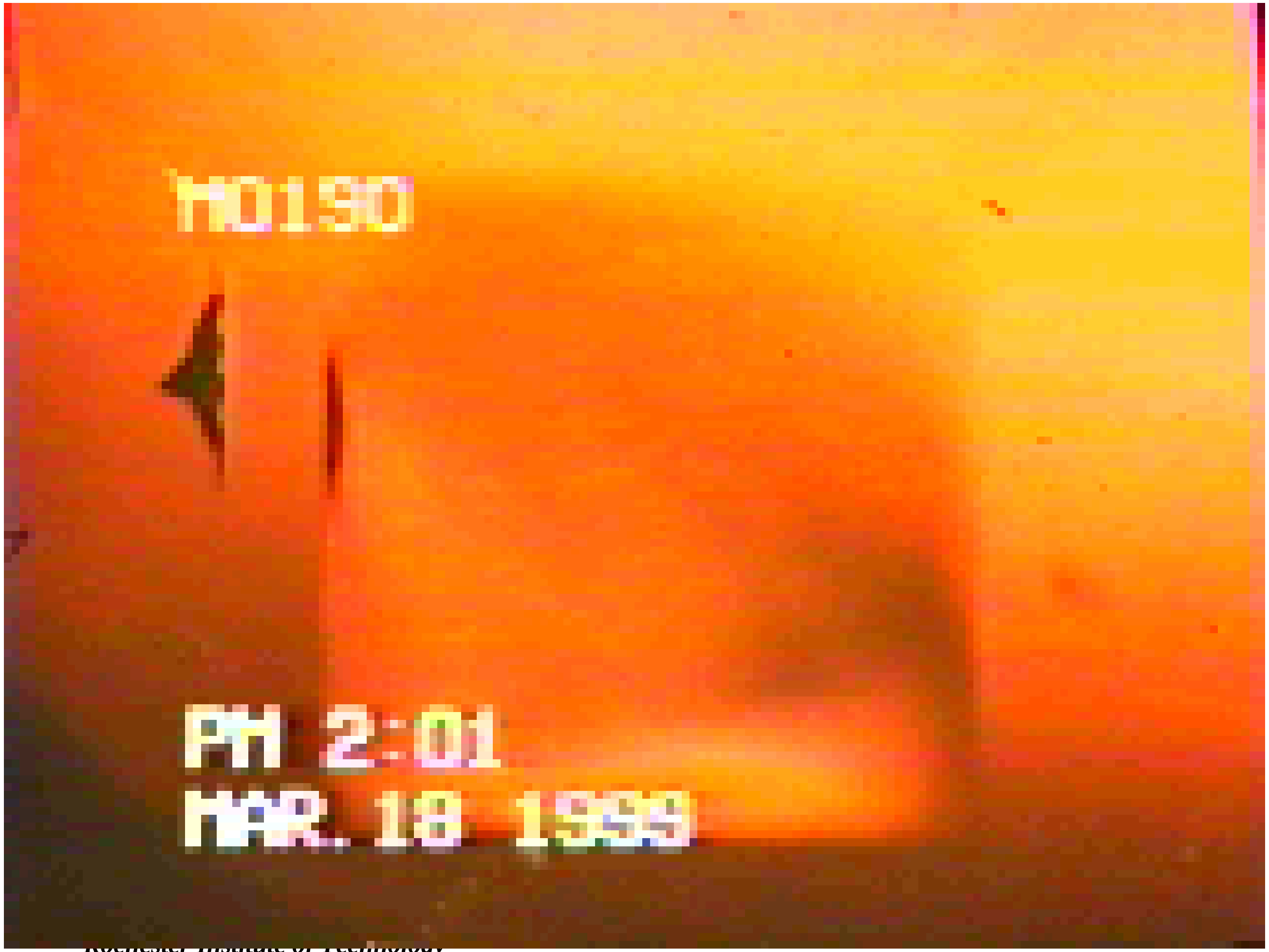
20% KOH Etch, @ 72 C, 10 Hrs.

PICTURES OF WAFER AFTER KOH ETCH

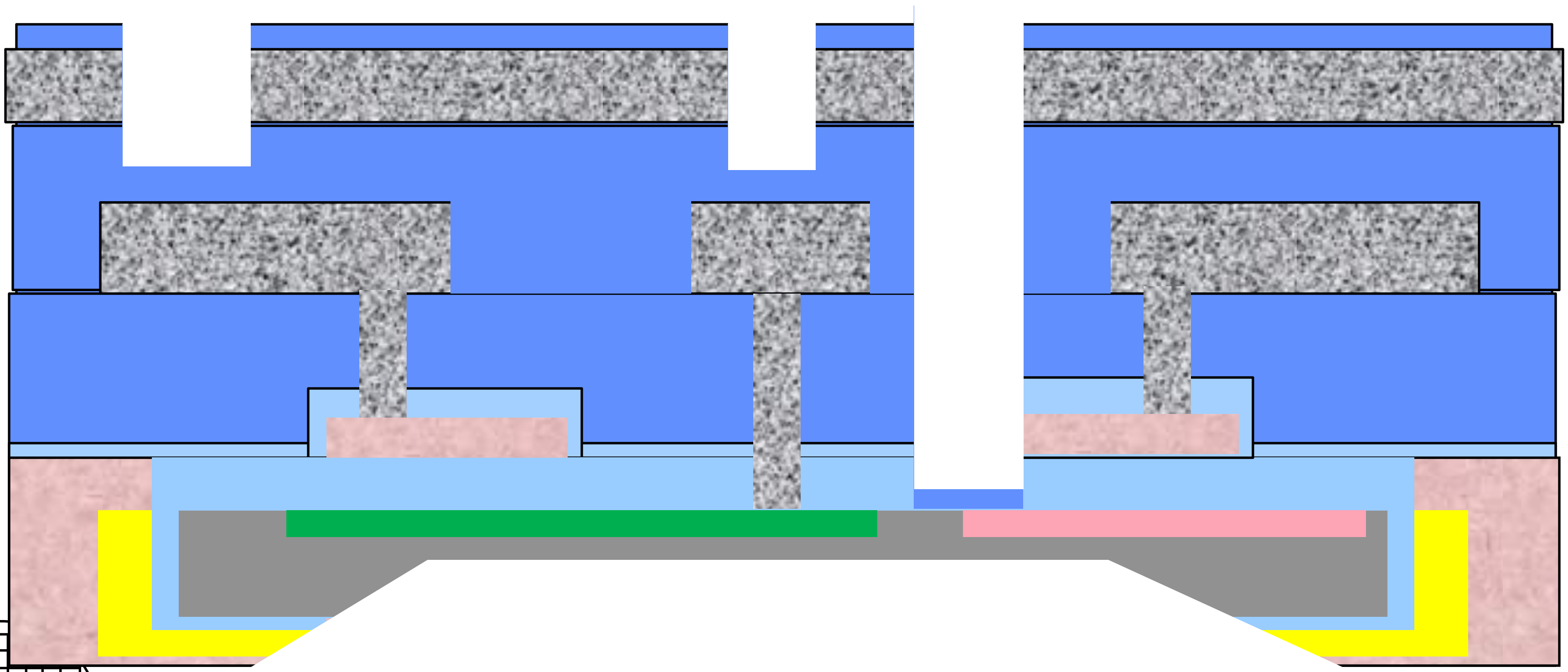
50 µm in 57 min ~.877 µm/min



VACUUM WAND CAUSES DIAPHRAGM TO DEFLECT

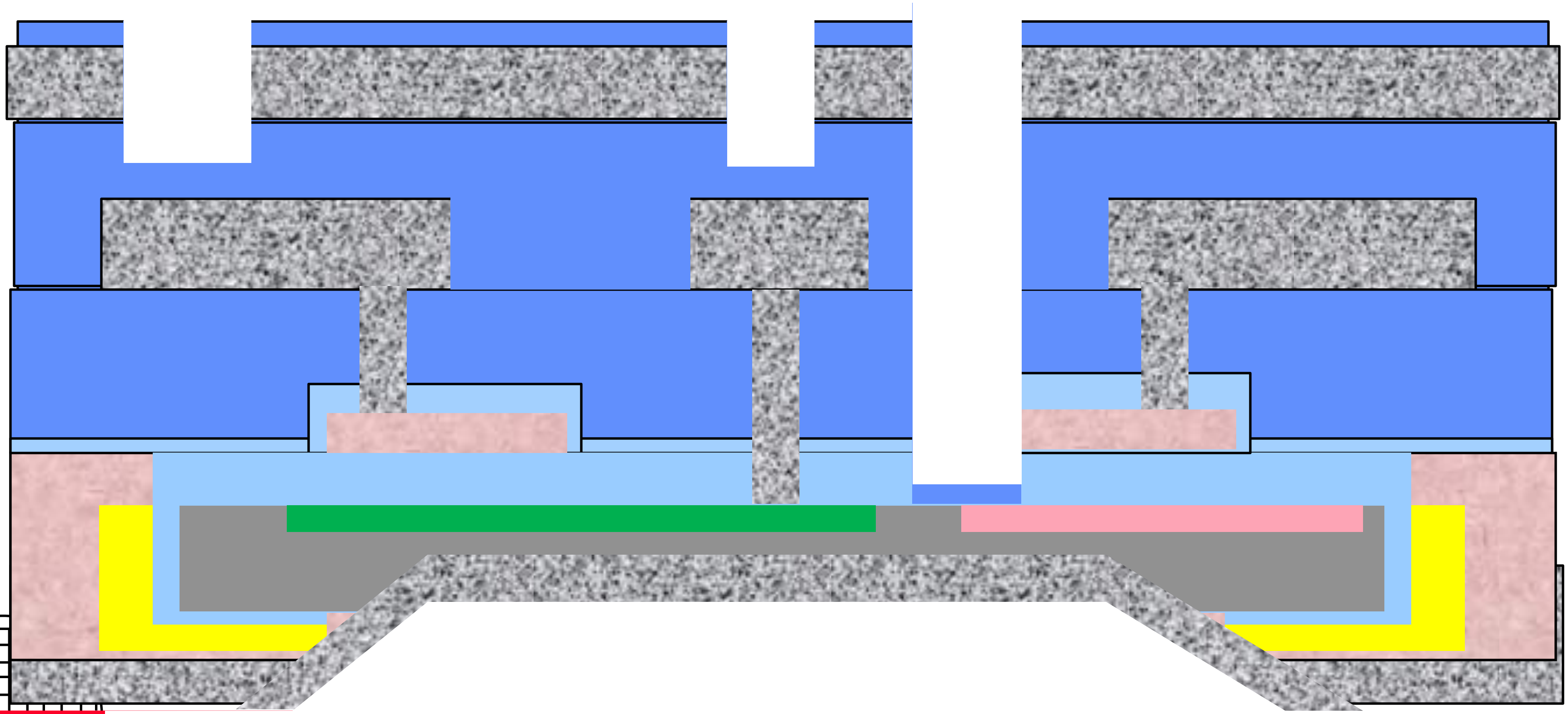


STRIP PROTEK



PUT ALUMINUM ON BACK SIDE OF WAFER

0.5 um of Aluminum on Back

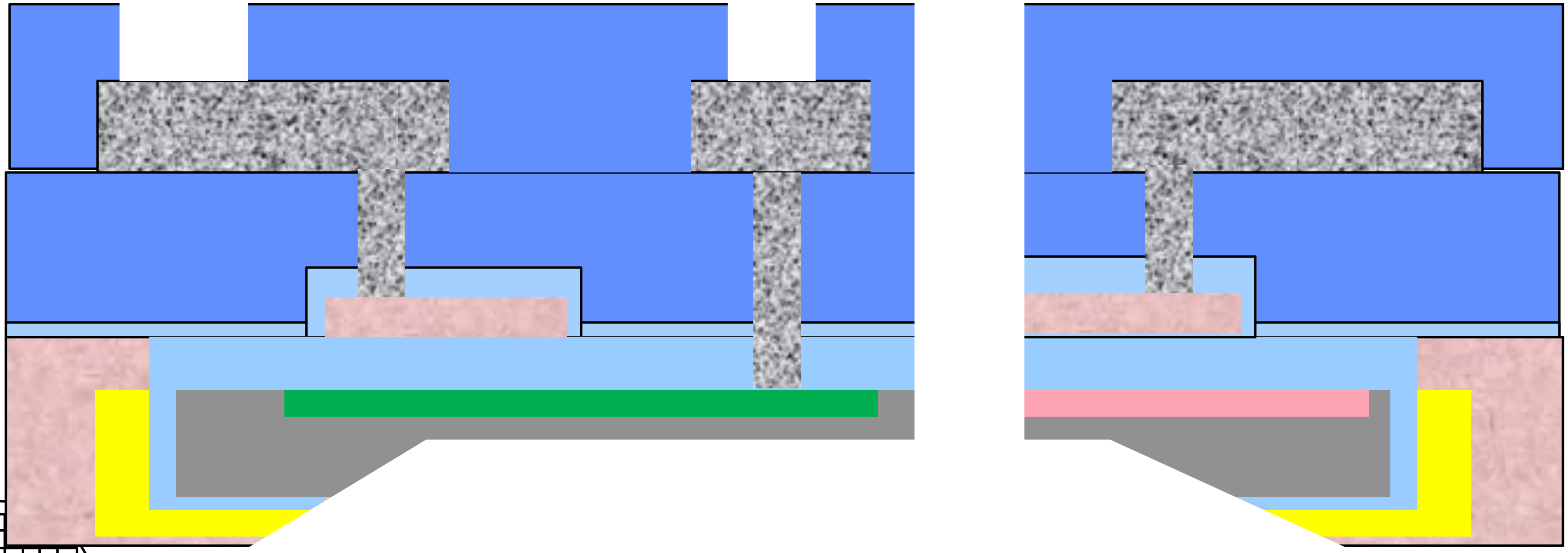


PLASMA ETCH TOP HOLE

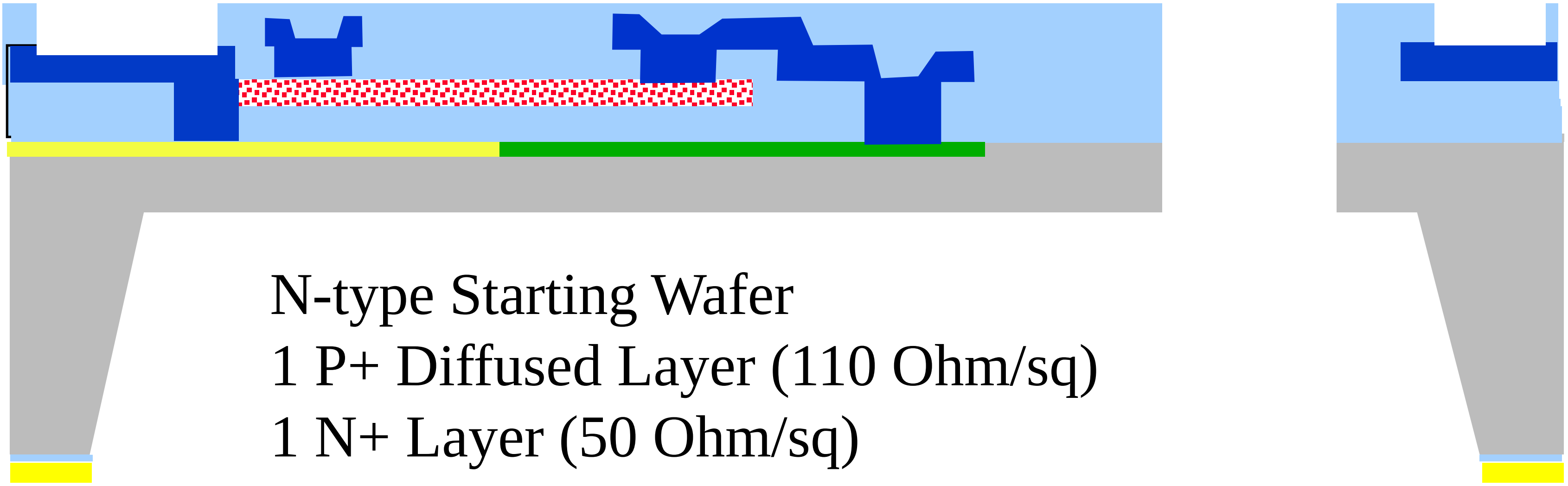
•Saw wafers
•Individual devices have been broken up in chips.
•Select the best chips and finish up the last steps of the process.
•Top hole etch in SF6+O2 in Lam490 or Drytek.
  •This removes top LTO, too.

•Remove top LTO if not removed during top hole etch.
•Remove Top Metal Aluminum etch ~3min
•Remove ILD1 LTO Pad etch ~ 4min
•Package and TEST ☺

STRIP LTO AND TOP METAL



RIT MEMS BULK PROCESS



N-type Starting Wafer

1 P+ Diffused Layer (110 Ohm/sq)

1 N+ Layer (50 Ohm/sq)

1 N-Poly layer (40 Ohm/sq)

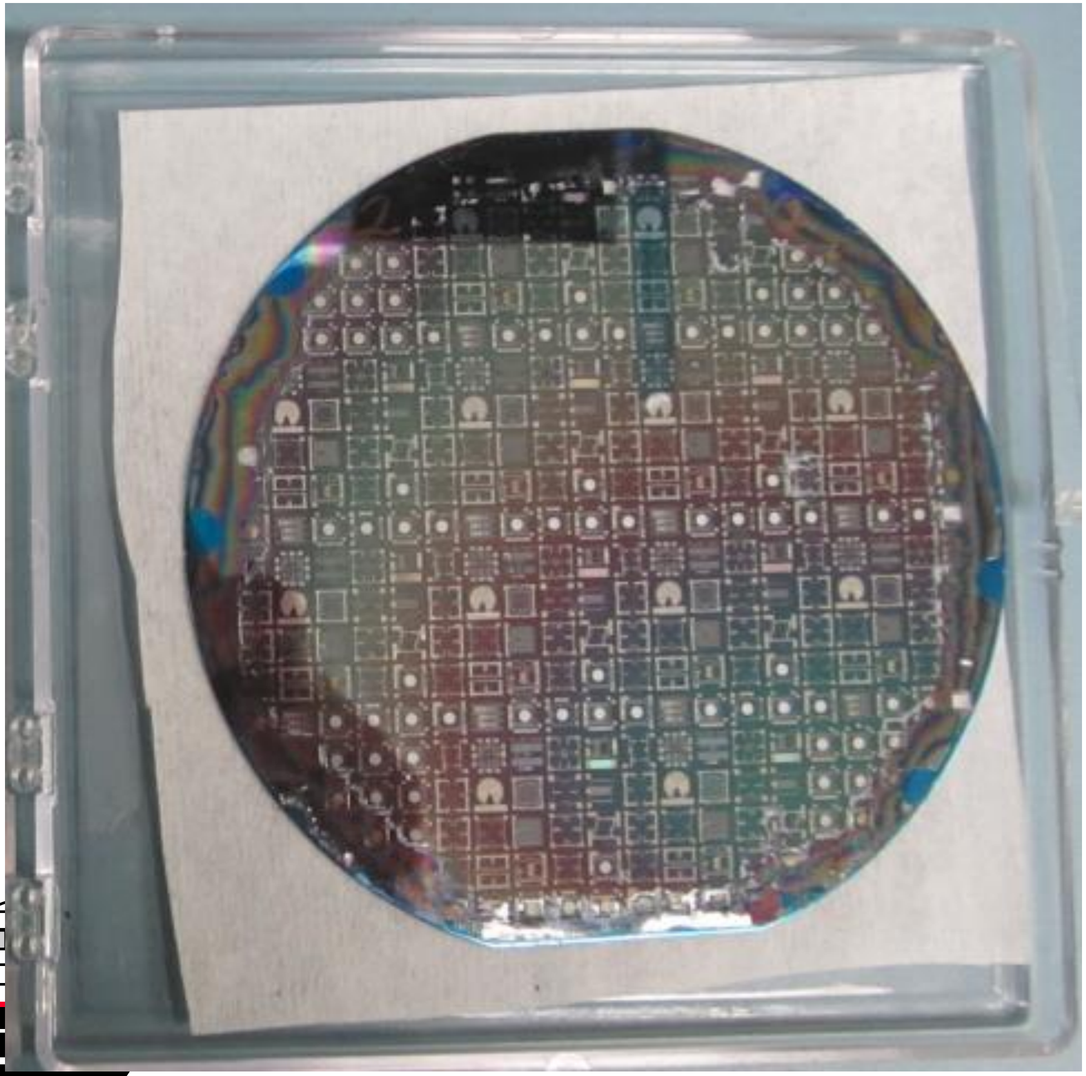
Contact Cut

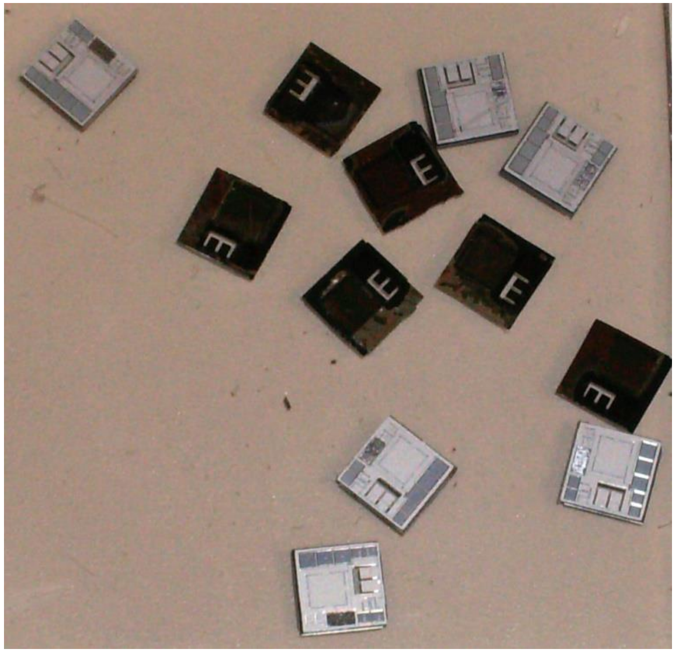
1 metal layer (Al 1µm thick)

Top Passivation and Top Hole

20-30 µm Si diaphragm

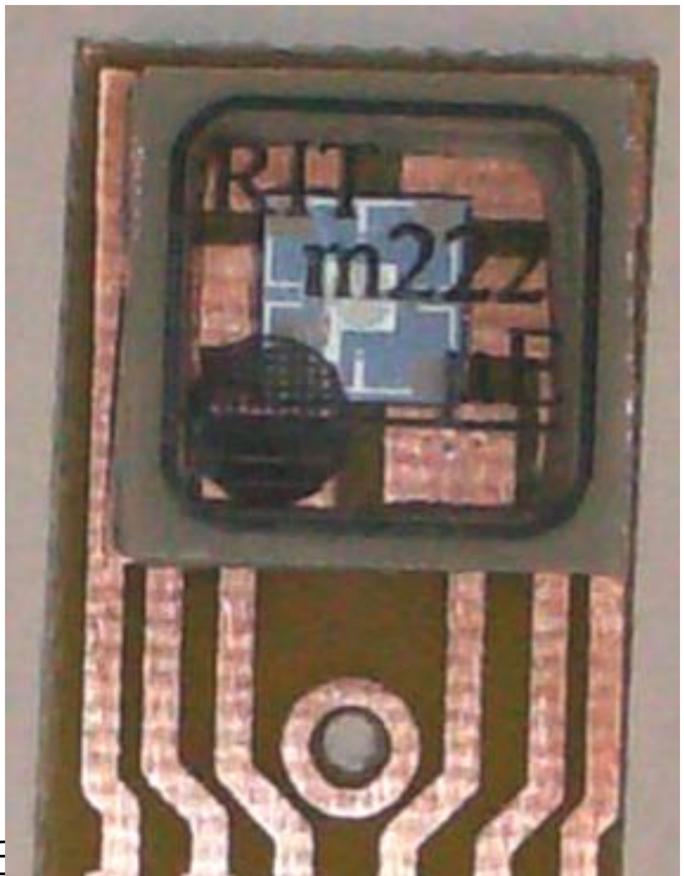
COMPLETED WAFER / CHIPS

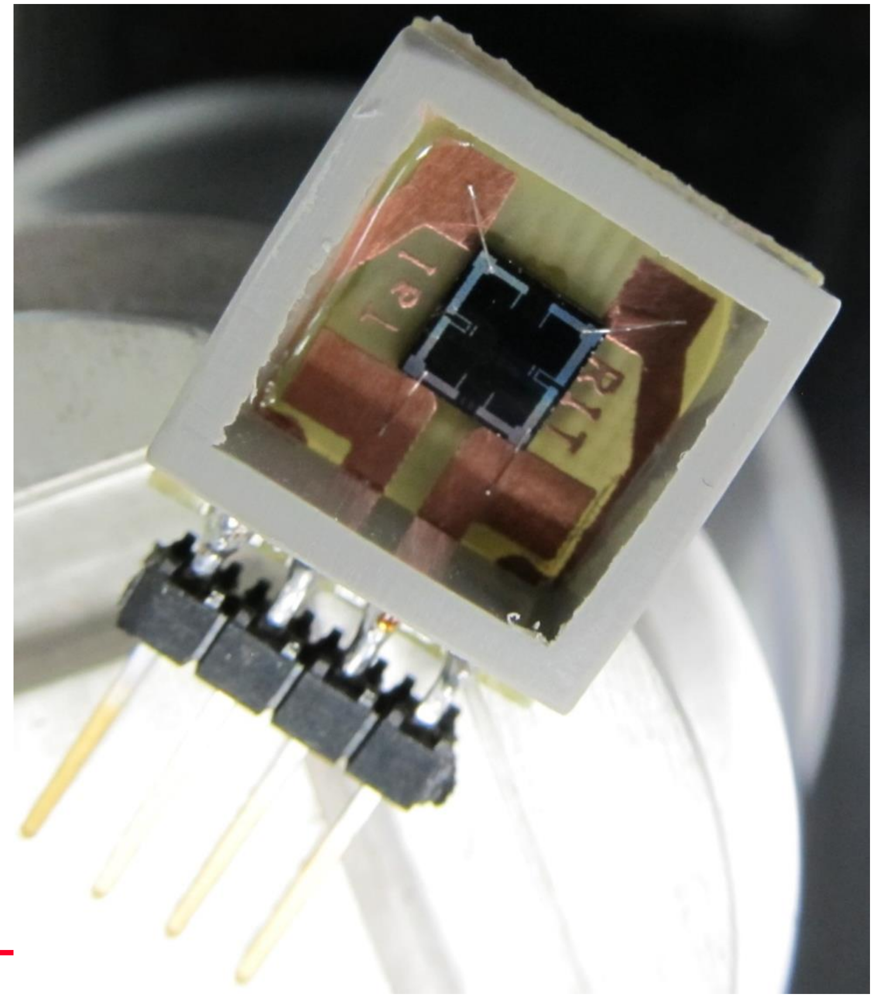




Top Hole is done on some chips

DICING, PACKAGING AND TESTING





REFERENCES

1. Process Development for 3 D Silicon Microstructures, with Application to Mechanical Sensor Devices, Eric Peeters, Katholieke Universiteit Leuven, March 1994.]
2. United States Patent 5,357,803
3. S.K. Clark and K.D. Wise, "Pressure Sensitivity in Anisotropically Etched Thin-Diaphragm Pressure Sensors", IEEE Transactions on Electron Devices, Vol. ED-26, pp 1887-1896, 1979.

HOMEWORK – BULK FABRICATION PROCESS

1. The fabrication sequence in this document has not been updated in several years. We have moved to 150mm wafer diameter and there are many new tools in the laboratory. If we use the STS Plasma Etcher it will enable many changes. Discuss these changes.