MEMS Bulk Fabrication Process

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MEMS Bulk Fabrication Process

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, $\lambda$
For the current MEMS process $\lambda$ is ten microns (10 $\mu$m)
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/memsbulk_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

Thermocouples and Heater

Accelerometer

Micro-pump
MULTI CHIP PROJECT LAYOUT
MASK LAYOUT
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
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 use our Electromet grinding tool and Strasbaugh CMP tool.
ELECTROMET GRINDING TOOL

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

Grinder

Wafer Thickness Measurement

Rochester Institute of Technology
Microelectronic Engineering
GRINDING DISC - FROM GRAINGER

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.

<table>
<thead>
<tr>
<th>Grainger Item #</th>
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<td>Catalog Page No.</td>
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<td>Country of Origin</td>
<td>USA</td>
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Grinding Disk
MEMS Bulk Fabrication Process

CMP BACKSIDE OF WAFERS

Strassbaugh CMP Tool

Rochester Institute of Technology
Microelectronic Engineering
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.

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

WRS-200
RCA CLEAN WAFERS

APM

H₂O – 4500ml
NH₄OH – 300ml
H₂O₂ – 900ml
75 °C, 10 min.

DI water rinse, 5 min.

DI water rinse, 5 min.

SPIN/RINSE DRY

HPM

H₂O – 4500ml
HCL – 300ml
H₂O₂ – 900ml
75 °C, 10 min.

DI water rinse, 5 min.

H₂O – 50 HF - 1
60 sec.

What does RCA stand for?

ANSWER

PLAY
GROW 5000 Å OXIDE

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

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
# OXIDE THICKNESS COLOR CHART

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>Tan</td>
</tr>
<tr>
<td>700</td>
<td>Brown</td>
</tr>
<tr>
<td>1000</td>
<td>Dark Violet - Red Violet</td>
</tr>
<tr>
<td>1200</td>
<td>Royal Blue</td>
</tr>
<tr>
<td>1500</td>
<td>Light Blue - Metallic Blue</td>
</tr>
<tr>
<td>1700</td>
<td>Metallic - very light Yellow Green</td>
</tr>
<tr>
<td>2000</td>
<td>Light Gold or Yellow - Slightly Metallic</td>
</tr>
<tr>
<td>2200</td>
<td>Gold with slight Yellow Orange</td>
</tr>
<tr>
<td>2500</td>
<td>Orange - Melon</td>
</tr>
<tr>
<td>2700</td>
<td>Red Violet</td>
</tr>
<tr>
<td>3000</td>
<td>Blue - Violet Blue</td>
</tr>
<tr>
<td>3100</td>
<td>Blue</td>
</tr>
<tr>
<td>3200</td>
<td>Blue - Blue Green</td>
</tr>
<tr>
<td>3400</td>
<td>Light Green</td>
</tr>
<tr>
<td>3500</td>
<td>Green - Yellow Green</td>
</tr>
<tr>
<td>3600</td>
<td>Yellow Green</td>
</tr>
<tr>
<td>3700</td>
<td>Yellow</td>
</tr>
<tr>
<td>3900</td>
<td>Light Orange</td>
</tr>
<tr>
<td>4100</td>
<td>Carnation Pink</td>
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<tr>
<td>4200</td>
<td>Violet Red</td>
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<tr>
<td>4400</td>
<td>Red Violet</td>
</tr>
<tr>
<td>4600</td>
<td>Violet</td>
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<tr>
<td>4700</td>
<td>Blue Violet</td>
</tr>
<tr>
<td>4900</td>
<td>Blue</td>
</tr>
<tr>
<td>5000</td>
<td>Blue Green</td>
</tr>
<tr>
<td>5200</td>
<td>Green</td>
</tr>
<tr>
<td>5400</td>
<td>Yellow Green</td>
</tr>
<tr>
<td>5600</td>
<td>Green Yellow</td>
</tr>
<tr>
<td>5700</td>
<td>Yellow -&quot;Yellowish&quot;(at times appears to be Lt gray or metal)</td>
</tr>
<tr>
<td>5800</td>
<td>Light Orange or Yellow - Pink</td>
</tr>
<tr>
<td>6000</td>
<td>Carnation Pink</td>
</tr>
<tr>
<td>6300</td>
<td>Violet Red</td>
</tr>
<tr>
<td>6800</td>
<td>&quot;Bluish&quot;(appears violet red, Blue Green, looks Blue)</td>
</tr>
<tr>
<td>7200</td>
<td>Blue Green - Green</td>
</tr>
<tr>
<td>7700</td>
<td>&quot;Yellowish&quot;</td>
</tr>
<tr>
<td>8000</td>
<td>Orange</td>
</tr>
<tr>
<td>8200</td>
<td>Salmon</td>
</tr>
<tr>
<td>8500</td>
<td>Dull, Light Red Violet</td>
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<tr>
<td>8600</td>
<td>Violet</td>
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<tr>
<td>8700</td>
<td>Blue Violet</td>
</tr>
<tr>
<td>8900</td>
<td>Blue</td>
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<tr>
<td>9200</td>
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<tr>
<td>9500</td>
<td>Dull Yellow Green</td>
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<tr>
<td>9700</td>
<td>Yellow - &quot;Yellowish&quot;</td>
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<tr>
<td>9900</td>
<td>Orange</td>
</tr>
<tr>
<td>10000</td>
<td>Carnation Pink</td>
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</table>

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

Eg. Yellow Nitride Thickness = (2000)(1.46/2.00) = 1460
INCIDENT WHITE LIGHT, THE INTENSITY OF THE REFLECTED LIGHT IS MEASURED VS WAVELENGTH

**MONOCHROMATOR & DETECTOR**

**WHITE LIGHT SOURCE**

**OPTICS**

**WAFFER**

**Reflectance Spectrometer**

3000 Å OXIDE

7000 Å OXIDE

- 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
WAFFER AFTER OXIDE GROWTH
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**
- 200 °C, 120 sec. Optional

**COAT**
- HMDS Vapor Prime
- S-8 RESIST 4500 rpm, 60 sec.

**SOFT BAKE**
- 90 °C
- 60 sec.

### DEVELOP

**POST EXPOSURE BAKE**
- 115 °C, 60 sec. Optional

**DEVELOP**
- DI Wet
- CD-26 Developer 50 sec., Puddle Rinse, Spin Dry

**HARD BAKE**
- 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

\[ \text{O}_2 + \text{Energy} = 2 \text{ O} \]

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

RF Power = 500 watts  
Heat Lamp = 500 watts for 10 sec.  
\text{O}_2 \text{ Flow} = 4500 \text{ sccm}  
Pressure = 4000 \text{ 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: Drive in dopant
Recipe 110
Recipe #110

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

1000°C

Boat Out  Boat In  Stabilize  Ramp-Up  Soak  Wet Oxide  Ramp-Down  Boat Out
Load  Push  800 °C  800 °C

25 °C

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 plus Wet 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
GROW MASKING OXIDE FOR N+ DIFFUSION

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

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\textsuperscript{ND} PHOTO – N+ DIFFUSION
ETCH OXIDE, STRIP RESIST AND RCA CLEAN

5.2:1 BOE 7 min.
Dopant diffusion – recipe 115
Etch SOG and masking oxide
N+ 6.7ohm/sq, P+ 110ohm/sq
Recipe #115

BRUCE FURNACE RECIPE 115 N+ DIFF & WET O2

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 (Si3N4) (normal - stociometric):
Temperature = 790-800-810 °C Ramp from (door to pump)
Pressure = 375 mTorr
3SiH2Cl2 + 4NH3 = Si3N4 + 9H2 + 3Cl2
Dichlorosilane (SiH2Cl2) Flow = 60 sccm
Ammonia (NH3) Flow = 150 sccm
Rate = 60 Å/min +/- 10 Å/min
Time ~25 min for 1500 Å
INCIDENT WHITE LIGHT, THE INTENSITY OF THE REFLECTED LIGHT IS MEASURED VS WAVELENGTH

**MONOCHROMATOR & DETECTOR**

**WHITE LIGHT SOURCE**

**OPTICS**

**WAFFER**

**REFLECTANCE SPECTROMETER**

**NANOSPEC THICKNESS MEASUREMENT**

- 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
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<tr>
<td>4600</td>
<td>Violet</td>
</tr>
<tr>
<td>4700</td>
<td>Blue Violet</td>
</tr>
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- **Nitride Thickness = (Oxide Thickness)(Oxide Index/Nitride Index)**
- **Eg. Yellow Nitride Thickness = (2000)(1.46/2.00) = 1460**
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**
  - 200 °C, 120 sec.
  - Optional
- **COAT**
  - HMDS Vapor Prime
  - S-8 RESIST
  - 4500 rpm, 60 sec.
- **SOFT BAKE**
  - 90 °C
  - 60 sec.

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

SVG Coat and Develop Track

Karl Suss MA-150
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
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.
Recipe #350

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
The objective is to plasma etch the nitride on 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
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
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
Recipe #120

**BRUCE FURNACE RECIPE 120- N+ POLY DOPE**

**1000°C**

<table>
<thead>
<tr>
<th>Interval 0</th>
<th>Interval 1</th>
<th>Interval 2</th>
<th>Interval 3</th>
<th>Interval 4</th>
<th>Interval 6</th>
<th>Interval 7</th>
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</thead>
<tbody>
<tr>
<td>Any</td>
<td>12 min</td>
<td>15 min</td>
<td>20 min</td>
<td>15 min</td>
<td>40 min</td>
<td>15 min</td>
</tr>
<tr>
<td>0 lpm</td>
<td>10 lpm</td>
<td>10 lpm</td>
<td>5 lpm</td>
<td>10 lpm</td>
<td>10 lpm</td>
<td>5 lpm</td>
</tr>
<tr>
<td>none</td>
<td>N2</td>
<td>N2</td>
<td>N2</td>
<td>N2</td>
<td>N2</td>
<td>N2</td>
</tr>
</tbody>
</table>

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**

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Verified: 2-24-04
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

\[ \rho_{\text{hos}} = \frac{\pi}{\ln 2} \times \frac{V}{I} = 4.532 \frac{V}{I} \text{ ohms/sq} \]

if \( S > x_j \)

\[ S = \text{probe spacing} \]

\[ x_j = \text{Diffusion Layer Thickness} \]

\[ V = 0.63 \text{ volts} \]
\[ I = 0.047 \text{ amps} \]
\[ \rho_{\text{hos}} = 61 \text{ ohms/sq} \]
Spin coat front
Expose, Develop and Hard Bake
Spin coat back and edges, bake (do not use SVG Track)
Coat edges by hand
Spin coat back and edges, bake (do not use SVG Track)
Coat edges by hand
SOLVENT STRIP, RCA CLEAN
POLY REOX
Recipe #250

Boat Out  Boat In
Load  Push  Stabilize
800 °C  800 °C

Ramp-Up  Soak  Anneal  Ramp-Down
1000°C

Boat Out
Pull
800 °C

Interval 0  Interval 1  Interval 2  Interval 3  Interval 4  Interval 5  Interval 6  Interval 7

25 °C

Any 12 min
0 lpm none

15 min 10 lpm N2

20 min 5 lpm O2

56 min 10 lpm O2

5 min 15 lpm N2

40 min 10 lpm N2

12 min 5 lpm 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.

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
Reduce Exposure to 15 seconds
**METAL ETCH**

Visual End Point ~ 4 min.
Inspect using microscope
INTER LEVEL OXIDE - 8000Å TEOS
TOP METAL LAYER – 7500 Å
7th Level Photo – Top Hole

Poly – 6000 Å
TOP METAL ETCH AND ILD ETCH

Poly – 6000 Å
REMOVE RESIST
PROTEK ADHESION LAYER OF TEOS
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

20 wt% KOH + IPA

Thermometer

Teflon Cover

Holes

Plastic Screw for Handle

Wafer Boat

Probe with glass cover

Wafers

Hot Plate

Controller

Teflon Stirrer & Guide Plate

70°C

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KOH ETCH BACK SIDE OF WAFFER
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.

500 µm

31 µm
PICTURES OF WAFER AFTER KOH ETCH

50 µm in 57 min ~ .877 µm/min
VACUUM WAND CAUSES DIAPHRAGM TO DEFLECT
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
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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

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REFERENCES

2. United States Patent 5,357,803
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.