Today’s Lecture

• Quiz 1 - Safety!!!
• Quiz 2 - Photolithography
• Discuss Traveler and Process
• Discuss Exposure Tool and Metrology Equipment
Take Quizzes

- Quiz 1 - Safety!!!
- Quiz 2 - Photolithography

Laboratory Process Flow

- Preliminary Fabrication
  - Week 0: Lab Orientation and Safety Instruction
  - Week 1: Polysilicon Etch
  - Week 2: Top Nitride Deposition and Etching
  - Week 3: Etch Top Nitride
  - Week 4: Etch Bottom Nitride
  - Week 5: Electrodeposition of Ni
  - Week 6: Electrodeposition of Ni
  - Week 7: KOH Etch (Release)
  - Week 8-9: Testing
  - Week 10: Lab Report Preparation
## Traveler

- **Contains step-by-step fabrication instructions**

<table>
<thead>
<tr>
<th>Type</th>
<th>Step Name</th>
<th>Description</th>
<th>Purpose</th>
<th>Initials</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR Stripper</td>
<td>11</td>
<td>Dehydration back</td>
<td>Hotplate, 150 °C, t &gt; 5 min</td>
<td>TA</td>
<td>Drive off moisture</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Adhesion coat</td>
<td>HMDS beaker, 10 min</td>
<td>TA</td>
<td>Improve adhesion</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Photoresist coat</td>
<td>AZ5214, 2 1/2 dropper, spin right away, 4000 rpm</td>
<td>TA</td>
<td>Deposit PR</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Softbake</td>
<td>Hotplate, 105 °C, 60 sec</td>
<td>TA</td>
<td>Drive out solvents</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Mask Aligner</td>
<td>Quintel, visual alignment, 15 sec exposure</td>
<td>TA</td>
<td>Transfer mask pattern</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>Development</td>
<td>AZ400K beaker, 60 sec, 6:1 solution, 2 min rinse</td>
<td>TA</td>
<td>Remove exposed PR</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>Dry Wafer</td>
<td>Careful N2 blow</td>
<td>TA</td>
<td>Remove water</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Inspection</td>
<td>Microscope</td>
<td>TA</td>
<td>Quality check</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>Hard bake</td>
<td>Hotplate, 120 °C, 2 min</td>
<td>TA</td>
<td>Strengthen resist</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Descum</td>
<td>Tegal plasma asher, 200 W, 0.5 mtorr, 2 min</td>
<td>TA</td>
<td>Remove PR scum</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>Etch</td>
<td>Deep Reactive Ion Etching, B59 recipe, 2 min</td>
<td>TA</td>
<td>Etch poly anisotropically</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>Inspection</td>
<td>Microscope</td>
<td>TA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>Piranha bath</td>
<td>Round beaker, add wafer, H2SO4 + H2O2 (5:1), mix, 10 min</td>
<td>TA</td>
<td>Strip PR</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>Rinse</td>
<td>DI beaker, medium flow, overflow rinse, 2 min, dry</td>
<td>TA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>Nitride Etch</td>
<td>LPCVD Nitride 800 °C, 4 hrs, target 1 µm, 35 cc SiCl2, 105 cc NH3</td>
<td>TA</td>
<td>Deposit thin nitride</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>Calculation</td>
<td>Subtract line 25 from line 37</td>
<td>TA</td>
<td>Nitride 2 thickness</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>Profilometer</td>
<td>4 measurements, look for “POLY”</td>
<td>TA</td>
<td>Pol thickness</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Stress</td>
<td>O2: 50, O2/Ar: 500 W, 13 min, check for conduction</td>
<td>TA</td>
<td>Remove backside poly</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>Strain</td>
<td>Quartz beaker, add water, H2SO4 + H2O2 (5:1), mix, 10 min</td>
<td>TA</td>
<td>Remove organics &amp; metals</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>Strain-stripping</td>
<td>100 W, 4.5 mtorr, 60 sec, nitrided, 100 sec, 10 mtorr</td>
<td>TA</td>
<td>Remove oxide</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>Stress</td>
<td>DI beaker, bend open, low water stream, 2 min, N2 dry</td>
<td>TA</td>
<td></td>
</tr>
</tbody>
</table>

### Data

<table>
<thead>
<tr>
<th>Type</th>
<th>Step Name</th>
<th>Description</th>
<th>Purpose</th>
<th>Initials</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>25</td>
<td>Nitride Etch</td>
<td>LPCVD Nitride 800 °C, 4 hrs, target 1 µm, 35 cc SiCl2, 105 cc NH3</td>
<td>TA</td>
<td>Deposit thin nitride</td>
</tr>
<tr>
<td>Data</td>
<td>28</td>
<td>Profilometer</td>
<td>4 measurements, look for “POLY”</td>
<td>TA</td>
<td>Pol thickness</td>
</tr>
<tr>
<td>Data</td>
<td>30</td>
<td>Stress</td>
<td>O2: 50, O2/Ar: 500 W, 13 min, check for conduction</td>
<td>TA</td>
<td>Remove backside poly</td>
</tr>
<tr>
<td>Data</td>
<td>32</td>
<td>Strain</td>
<td>Quartz beaker, add water, H2SO4 + H2O2 (5:1), mix, 10 min</td>
<td>TA</td>
<td>Remove organics &amp; metals</td>
</tr>
<tr>
<td>Data</td>
<td>34</td>
<td>Strain-stripping</td>
<td>100 W, 4.5 mtorr, 60 sec, nitrided, 100 sec, 10 mtorr</td>
<td>TA</td>
<td>Remove oxide</td>
</tr>
<tr>
<td>Data</td>
<td>35</td>
<td>Stress</td>
<td>DI beaker, bend open, low water stream, 2 min, N2 dry</td>
<td>TA</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Members</th>
<th>Lab Section</th>
<th>Wafer: #</th>
<th>Data</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>28</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>32</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>34</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>35</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>36</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>37</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>38</td>
<td></td>
</tr>
</tbody>
</table>
Processing Steps Already Performed on Your Wafer

- Photolithography #1
  - Resistors (sensing elements)
  - Labels
  - Sacrificial pads
  - Heating elements
- Dry etching of polysilicon
- Deposition of nitride
Nanospec (file thickness)

SI SUBSTRATE ~500 µm
SILICON NITRIDE 1 µm
POLYSILICON 1 µm

TOP VIEW Deposit and Dope Semiconductor (Poly)

CROSS SECTION A-A':
QUINTEL (CONTACT EXPOSURE / ALIGNMENT)

PHOTOLITHOGRAPHY MASK (POLY):

Resistor Mask

LAYOUT CAPTURE:
 Deposit and Pattern PR

CROSS SECTION A-A':

Etch Poly to Form Sensing Element

CROSS SECTION A-A':
Tegal Asher (etch organics)

TOP VIEW:

Remove PR

CROSS SECTION A-A':

- Silicon Nitride 1 µm
- Si Substrate ~500 µm
Alphastep Profilometer

Etch Backside Poly

TOP VIEW:

CROSS SECTION A-A':

- SILICON NITRIDE 1 μm
- SI SUBSTRATE ~500 μm
**Insulate Sensing Element**

**CROSS SECTION A-A':**

- Silicon Nitride 1 µm
- Polysilicon 1 µm
- Silicon Nitride 1 µm
- Si Substrate ~500 µm

**TOP VIEW:**

- A
- A'

**PHOTOLITHOGRAPHY MASK (VIA):**

**LAYOUT CAPTURE:**

- REGION SHOWN ON TOP AND CROSS SECTION VIEWS
Accelerometer

WEEK 2

WEEK 3

NITRIDE 2 ON POLY

NITRIDE 2 ON NITRIDE 1

VIA TO POLY

Magnetic Sensor

WEEK 2

WEEK 3

NITRIDE 2 ON NITRIDE 1

VIA TO POLY
Magnetic Actuator

- WEEK 2
- WEEK 3

Pressure Sensor

- WEEK 2
- WEEK 3
## Using Traveler on Tidal Wave

### EE150L Fall 2002 Process of Record: Week 3

<table>
<thead>
<tr>
<th>Type</th>
<th>Step</th>
<th>Name</th>
<th>Description</th>
<th>Purpose</th>
<th>Initials</th>
<th>Observations / Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>39</td>
<td>Dehydration</td>
<td>Hotplate, 150 °C, t &gt; 5 min</td>
<td>Drive off moisture</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>Adhesion coat</td>
<td>HMDS beaker, 10 min</td>
<td>Improve adhesion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>41</td>
<td>Photoresist coat</td>
<td>STR1045, 1 full dropper, spin right away, 4000 rpm</td>
<td>Deposit PR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>42</td>
<td>Softbake</td>
<td>Hotplate, 105 °C, 60 sec</td>
<td>Drive out solvents</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>43</td>
<td>Mask Aligner</td>
<td>Quintel, alignment, 15 sec exposure</td>
<td>Transfer mask pattern</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>44</td>
<td>Development</td>
<td>Dev351 beaker, 45 sec, 4:1 solution, 1 min rinse</td>
<td>Remove exposed PR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>46</td>
<td>Inspection</td>
<td>Microscope</td>
<td>Alignment check</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>47</td>
<td>Hard bake</td>
<td>Hotplate, 120 °C, 2 min</td>
<td>Strengthen resist</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>Etch</td>
<td>Oxford etcher, recipe 5, time = line 38 / (51 nm/min)</td>
<td>Define structural layer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>49</td>
<td>Inspection</td>
<td>Over etch check for conduction</td>
<td>Ensure full completion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>Hard Bake</td>
<td>Hotplate, 120 °C, 2 min</td>
<td>Strengthen resist</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>Overetch</td>
<td>HCL, HNO3, H2O2 (5:1), mix, 10 min</td>
<td>Remove organics &amp; metals</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>52</td>
<td>Calculation</td>
<td>Divide line 52 by line 48</td>
<td>Nitride etch rate in CH3 + O2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>53</td>
<td>Calculation</td>
<td>Subtract line 53 from line 52</td>
<td>Overetch =</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Photolithography, Process Flow, Dry Etching

**TOP VIEW:**

**Deposit and Pattern PR**

**CROSS SECTION A-A':**

**PHOTORESIST 5 µm**

**SILICON NITRIDE 1 µm**

**SILICON NITRIDE 1 µm**

**SI SUBSTRATE ~500 µm**
Alignment Marks

- **Purpose**
  - Allow layers to be aligned to one another precisely
- **Location**
  - Bottom right on every die
  - Arrows in chip point to it

---

**TOP VIEW** Etch Top Insulator to Access Poly (Vias)

**CROSS SECTION A-A’:**

- PHOTORESIT 5 µm
- SILICON NITRIDE 1 µm
- SILICON NITRIDE 1 µm
- SI SUBSTRATE ~500 µm
EE M150L Lecture 2: Photolithography, Process Flow, Dry Etching
Jack W. Judy © 2003

Oxford RIE Nitride Etcher

TOP VIEW:
Remove PR

CROSS SECTION A-A':

SI SUBSTRATE ~500 µm
SILICON NITRIDE 1 µm
POLYSILICON 1 µm
SILICON NITRIDE 1 µm
SILICON NITRIDE 1 µm
SI Substrate ~900 µm
EE M150L Lecture 2: Photolithography, Process Flow, Dry Etching

Jack W. Judy © 2003

TOP VIEW: Etch Nitride to Define Device Structures

CROSS SECTION A-A':

TOP VIEW: Remove PR

CROSS SECTION A-A':
PHOTOLITHOGRAPHY MASK (NITB): Backside Opening Mask

LAYOUT CAPTURE:

REGION SHOWN ON TOP AND CROSS SECTION VIEWS


TOP VIEW: Deposit and Pattern PR on Backside

CROSS SECTION A-A':

SI SUBSTRATE ~500 µm
SILICON NITRIDE 1 µm
POLYSILICON 1 µm
SILICON NITRIDE 1 µm
SI SUBSTRATE ~500 µm
Etch Holes on Backside Nitride

CROSS SECTION A-A':

Remove PR

CROSS SECTION A-A':
PHOTOLITHOGRAPHY MASK (NIC1, FIRST TIME): **Seed Layer Mask**

LAYOUT CAPTURE:

SI SUBSTRATE ~500 µm
SILICON NITRIDE 1 µm
POLYSILICON 1 µm
SILICON NITRIDE 1 µm
PHOTORESIT 5 µm

TOP VIEW: **Deposit and Pattern PR**

CROSS SECTION A-A':

PHOTORESIT 5 µm
SILICON NITRIDE 1 µm
SILICON NITRIDE 1 µm
SI SUBSTRATE ~500 µm
EE M150L Lecture 2: Photolithography, Process Flow, Dry Etching

Jack W. Judy © 2003

Deposit Metal (Seed Layer)

CROSS SECTION A-A':

CHROMIUM 10 nm / NICKEL 100 nm
PHOTORESIST 5 µm
SI SUBSTRATE ~500 µm
SILICON NITRIDE 1 µm
POLYSILICON 1 µm
SILICON NITRIDE 1 µm

TOP VIEW:

Remove PR and Some Metal

CROSS SECTION A-A':

CHROMIUM 10 nm / NICKEL 100 nm
SI SUBSTRATE ~500 µm
Deposit Conduction Layer

Cross Section A-A':

TITANIUM 200 nm

SILICON NITRIDE 1 µm

SI SUBSTRATE ~500 µm

POLYSILICON 1 µm

SILICON NITRIDE 1 µm

TITANIUM 200 nm

PHOTOGRAPHY MASK (NIC1, SECOND TIME): Interconnect Mask

Layout Capture:

Region shown on top and cross section views
TOP VIEW: Deposit and Pattern PR

CROSS SECTION A-A':

TOP VIEW: Remove Conduction Layer over Seed Layer

CROSS SECTION A-A':

SI SUBSTRATE \(~500 \mu m\)

PHOTORESIT 5 \(\mu m\)

SILICON NITRIDE 1 \(\mu m\)

POLYSILICON 1 \(\mu m\)

SILICON NITRIDE 1 \(\mu m\)
Deposit Metal (Wires)

TOP VIEW:

CROSS SECTION A-A':

Remove PR

TOP VIEW:

CROSS SECTION A-A':
PHOTOLITHOGRAPHY MASK (NIC2): Proof Mass Mask

LAYOUT CAPTURE:

REGION SHOWN ON TOP AND CROSS SECTION VIEWS

TOP VIEW:
Deposit and Pattern PR

CROSS SECTION A-A':

SI SUBSTRATE ~500 µm
SILICON NITRIDE 1 µm
POLYSILICON 1 µm
SILICON NITRIDE 1 µm
NICKEL 5 µm
PHOTORESIST 5 µm
SI SUBSTRATE ~500 µm
Electroplating (Proof Mass)

CROSS SECTION A-A':

TOP VIEW:

Remove PR

CROSS SECTION A-A':

TOP VIEW:
Remove Conduction Layer

CROSS SECTION A-A':

NICKEL 5 \( \mu m \)
SILICON NITRIDE 1 \( \mu m \)
SILICON NITRIDE 1 \( \mu m \)
SI SUBSTRATE ~500 \( \mu m \)

NICKEL 40 \( \mu m \)

Release Devices

CROSS SECTION A-A':

NICKEL 5 \( \mu m \)
CHROMIUM 10 nm / NICKEL 100 nm
SILICON NITRIDE 1 \( \mu m \)
SILICON NITRIDE 1 \( \mu m \)
SI SUBSTRATE ~500 \( \mu m \)

NICKEL 40 \( \mu m \)
Next Lecture

• Preparation (Readings):
  – Read Chapter 4:
    • Section 4.8 (Equipment)
  – Read the traveler
    • for this week on page 117

• Lecture:
  – Quiz 3 – Process Flow / Etching
  – Discuss Traveler and Process
  – Discuss Front-to-Backside Alignment
  – PTE Numbers