Today’s Lecture

- Quiz 5 – E-Beam, Lift Off
- Discuss Traveler and Process
- Plating
- Seed Layer
- Cross Sections
- Device Pictures
### Electrodeposition

- **Method for depositing metal on conductive surfaces**
  - Fast deposition
    - Evaporation: 1.0 µm/min (Ni)
    - Electroplating: 10 µm/hr (Ni)
    - Sputtering: 0.1 µm/hr (Ni)
  - Cheap
- **Purpose**
  - Create interconnect wire (this week)
  - Proof masses and ferromagnetic element (next week)
- **Equipment**
  - Aqueous-metal solution
  - Power supply
  - Nickel source

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#### Traveler

<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>100</td>
<td>Dehydration</td>
<td>Hotplate, 150 °C, 5 min</td>
<td>Drive off moisture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>101</td>
<td>Adhesion coat</td>
<td>HMDS beaker, 10 min</td>
<td>Improve adhesion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>102</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>103</td>
<td>Softbake</td>
<td>Hotplate, 105 °C, 60 sec</td>
<td>Drive out solvents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>104</td>
<td>Mask Aligner</td>
<td>Quintel, alignment, 15 sec exposure</td>
<td>Transfer mask pattern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>105</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>106</td>
<td>Dry Wafer</td>
<td>Careful N2 blow</td>
<td>Remove water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>107</td>
<td>Inspection</td>
<td>Microscope</td>
<td>Alignment check</td>
<td></td>
<td></td>
</tr>
<tr>
<td>108</td>
<td>Inspection</td>
<td>Microscope</td>
<td>Quality check</td>
<td></td>
<td></td>
</tr>
<tr>
<td>109</td>
<td>Hard bake</td>
<td>Hotplate, 120 °C, 2 min</td>
<td>Strengthen resist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>Descum</td>
<td>Tegal plasma asher, 200 W, 0.5 mtorr, 2 min</td>
<td>Remove PR scum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>111</td>
<td>Etch</td>
<td>4 mL HF, 400 mL H2O, 90 sec</td>
<td>Remove Ti from lift off layer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>112</td>
<td>Surface treatment</td>
<td>Nickel strike soln, 25 mA/cm², 30 sec, rinse, dry</td>
<td>Roughen surface</td>
<td></td>
<td></td>
</tr>
<tr>
<td>113</td>
<td>Deposition</td>
<td>Nickel plating, 10 mA/cm², 40 min, rinse, dry</td>
<td>Create interconnect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>114</td>
<td>Calculation</td>
<td>Add line 111 to line 115 (if &gt; 5 microns, then proceed)</td>
<td>Total nickel 1 plated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>115</td>
<td>Calculation</td>
<td>Divided by line 111 to line 114</td>
<td>Nickel dep rate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Electrodeposition**

- Dip source and wafer in solution
- Apply current from source (V+) to wafer (V-)
- Ni atoms from source loose electrons and leave the source
- Positive ions in solution gain electrons on surface of wafer
- Deposition takes place

<table>
<thead>
<tr>
<th>Anode (Etching)</th>
<th>Cathode (Deposition)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ni(s) $\rightarrow$ Ni$^{2+}$(aq) + 2e$^-$</td>
<td>Ni$^{2+}$(aq) + 2e$^-$$ \rightarrow$ Ni(s)</td>
</tr>
</tbody>
</table>

**Through-Mask Plating on Seed Layer**

1. Deposit Seed Layer
2. Define Plating Mask
3. Electroplate Material
4. Remove Mask / Seed
Mass Production with Electroplating

- high-volume batch-fabricated ferromagnetic microstructure
- multiple levels of ferromagnetic material and conductor

Electroplating Challenges

- The trick is getting consistent film properties
  - plating of hydrogen (electrolysis) consumes electrons and reduces film thickness
  - stress is a function of deposition rate, temperature, pH, ...
  - alloy composition is also a function of many plating parameters
- Commercial plating baths are available
  - Technic, Inc., Enthone-OMI, ...
  - includes many additives, but they are proprietary
Cross Sections

Deposit Insulator (Nitride)

TOP VIEW:

CROSS SECTION A-A':

SI SUBSTRATE ~500 µm

SILICON NITRIDE 1 µm
TOP VIEW: Deposit and Dope Semiconductor (Poly)

CROSS SECTION A-A':

PHOTOLITHOGRAPHY MASK (POLY): Resistor Mask

REGION SHOWN ON TOP AND CROSS SECTION VIEWS
**EE M150L Lecture 5: Plating**

**Top View:**

Deposit and Pattern PR

**Cross Section A-A':**

Etch Poly to Form Sensing Element
Remove PR

Etch Backside Poly
Insulate Sensing Element

CROSS SECTION A-A':

PHOTOLITHOGRAPHY MASK (VIA):

LAYOUT CAPTURE:
Deposit and Pattern PR

CROSS SECTION A-A':

Etch Top Insulator to Access Poly (Vias)
Remove PR

CROSS SECTION A-A':

PHOTOLITHOGRAPHY MASK (NITT):
Device Structure Mask

LAYOUT CAPTURE:
Deposit and Pattern PR

TOP VIEW:

CROSS SECTION A-A':

Etch Nitride to Define Device Structures

TOP VIEW:

CROSS SECTION A-A':
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**TOP VIEW:** Deposit and Pattern PR on Backside

**CROSS SECTION A-A':**

**TOP VIEW:** 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:
Deposit and Pattern PR

CROSS SECTION A-A':

TOP VIEW:

Deposit Metal (Seed Layer)

CROSS SECTION A-A':

TOP VIEW:
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Remove PR and Some Metal

CROSS SECTION A-A':

CHROMIUM 10 nm / NICKEL 100 nm

Before Uniform Ti Evaporation

EE M150L Lecture 5: Plating
TOP VIEW:

**Deposit and Pattern PR**

CROSS SECTION A-A':

TOP VIEW:

**Remove Conduction Layer over Seed Layer**

CROSS SECTION A-A':
TOP VIEW:

Deposit Metal (Wires)

CROSS SECTION A-A':

After Plating Before PR Strip
EE M150L Fall 2002 Chip

- Accelerometer
- Pressure Sensor
- Contact Resistance
- Nitride Etch Completion Structures
- Stress Gauges
- Resolution Features
- Thermal Actuator
- Neuroprobe
- Magnetic Sensor
- Magnetic Actuator
- Cantilever Beams
- Alignment Marks
- Profilometer Features

Torsional Magnetometer
Pressure Sensor Interconnects

Magnetic Microactuator
Thermal Actuators with Heaters

Remove PR

TOP VIEW:

CROSS SECTION A-A':

SI SUBSTRATE ~500 µm
SILICON NITRIDE 1 µm
POLYSILICON 1 µm
SILICON NITRIDE 1 µm
NICKEL 5 µm
SI SUBSTRATE ~500 µm
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Remove Conduction Layer

Cross section A-A':

- Si substrate ~500 µm
- Silicon nitride 1 µm
- Polysilicon 1 µm
- Silicon nitride 1 µm
- Chromium 10 nm / Nickel 100 nm
- Nickel 5 µm
- Nickel 40 µm

Cross section A-A':

- Si substrate ~500 µm
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- Silicon nitride 1 µm
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- Nickel 40 µm

Release Devices

Cross section A-A':

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- Silicon nitride 1 µm
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