EE M150: Introduction to Micromachining and MEMS

Lecture:

Deposition:
Electrodeposition

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Lecture Outline

• Readings:
  – Madou, Chapter 6: 345-357 (Electrodeposition)

• Topics:
  – Electroplating
Electrodeposition

\[ \begin{align*}
\text{Anode (Deposition)} & : 
\text{Ni(s)} & \rightarrow & \text{Ni}^{2+}(\text{aq}) + 2e^- \\
\text{Cathode (Deposition)} & : 
\text{Ni}^{2+}(\text{aq}) + 2e^- & \rightarrow & \text{Ni(s)}
\end{align*} \]

- Nickel Anode is consumed / replenished
- In NiFe baths, Fe is consumed
  - must be replenished

Nickel Plating Solution

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nickel Sulfate</td>
<td>200 g/l</td>
</tr>
<tr>
<td>Nickel Chloride</td>
<td>5 g/l</td>
</tr>
<tr>
<td>Boric Acid</td>
<td>25 g/l</td>
</tr>
<tr>
<td>Ferrous Sulfate</td>
<td>8 g/l</td>
</tr>
<tr>
<td>Saccharin</td>
<td>3 g/l</td>
</tr>
</tbody>
</table>

pH = 4 and room temperature

Selective Deposition: One-Mask Process

1. Deposit Seed Layer
2. Define Plating Mask
3. Electroplate Material
4. Remove Mask / Seed
Plating – Practical Issues

- thickness not limited by mask thickness
- plating mask must achieve good step coverage
- adhesion layer (Ni adheres poorly to Si)

Electrodeposit: Mechanical Adhesion

- plate film in a mechanically adhering configuration
- can reduce (eliminate) the need for an adhesion layer
Electroplating: Current Crowding

- non-uniform current density
- non-uniform deposition rate (thickness)
- non-uniform composition (Permalloy)

Selective Deposition: Two-Mask Process

- uniform current density in area of interest
- uniform deposition rate, thickness, and composition
- used for thin-film magnetic recording heads
- more complex fabrication process
Thin-Film Magnetic Recording
Write Head

- 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
Next Lecture

• Reading for next lecture:
  – Wolf and Tauber: 618-646
    (Design of Experiments)