Fabrication of Suspended Aluminum Beams

EECS 199
Prof. Nelson
Prof. LaRue
Prof. Kine

By

Lindel Kabalican
Chris Cheng
Objective

Our objective for this project is to develop a fabrication process for suspended aluminum beams of various widths on a quarter wafer that will be used to calculate Young’s Modulus of the aluminum.

Introduction

Brandon Choi, who helped in training Chris and I in RCA cleaning, wafer cutting, and photolithography, developed the initial fabrication process. The process is used for 3 um thick aluminum deposited on quarter silicon wafers through thermal evaporation. Two different iron oxide masks will be used in this procedure. The first iron oxide mask is to create the structures during the photolithography process. It contains multiple sets of 5 beams. Four of the beams are anchored at both ends: two with a width of 100 um and two with a width of 50 um. The last beam is a cantilever, one end anchored, with a width of 100 um. The length of the aluminum beams is 500 um, while the length of the cantilever is 350 um. This is a picture of the resulting structure before the silicon etching that is similar to a single set on the mask.

![Image of structure](image)

The second mask will be used in the silicon etching process to prevent undercutting at the anchored ends of the beams. The silicon is to be etched to a depth of 50 – 100 um to allow the beams to be free standing structures. We will then use the profilometer to run its needle over each anchored beam to measure its deflection as it is probed across the beam. With the width, length, and deflection, we will be able to calculate Young’s modulus of the 3 um thick suspended aluminum beams.
Equipment

1. Beaker
2. Laurell Photoresist Spinner
3. Mask Aligner
4. Thermal Evaporator
5. 2 Iron Oxide Masks
6. Dektac (Profilometer)
7. Scanning Electron Microscope (SEM)

Procedure

Note: Test grade SI wafer. N-type

1) RCA-1 Cleaning of whole Si wafer
   Materials:
   - 325 ml water
   - 65 ml Hydrogen Peroxide (H₂O₂)
   - 65 ml Ammonium Hydroxide (NH₄OH)

2) Cut wafers into quarters using diamond scribe.

3) Deposit 3 um (30 kA) of 99.999% Al using the thermal evaporator.

4) Start of Photolithography.
   a. Spin on THICKNESS photoresist, 1827, using photoresist spinner.
      i. Acceleration: 500 rpm
      ii. Speed: 3500 rpm
      iii. Time: 30 seconds
   b. Bake at 90 degrees Celsius for 20 to 30 min.
   c. Expose for 15 seconds with first mask.
   d. Develop using photolithography developer.

5) End of Photolithography.

6) PAN etch to create aluminum structure protected by photoresist.
   Materials:
   - 80% H₃PO₄
   - 5% HNO₃
   - 5% CH₃COOH
   - 10% H₂O

7) Use acetone to remove photoresist protecting the structure.

8) Use Profilometer to measure height of the aluminum structure before Si etch.

9) Use SEM to measure widths and lengths of the Al beams.

10) End of our procedure.

Note: Due to training, we were not able to develop a process to etch the silicon.
3 um Al Results before Si Etch

Widths

Note: Used SEM for these results.

<table>
<thead>
<tr>
<th>Beam</th>
<th>1st Measurement (um)</th>
<th>2nd Measurement (um)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st 50 um</td>
<td>31.75</td>
<td>53.13</td>
</tr>
<tr>
<td>2nd 50 um</td>
<td>30.90</td>
<td>50.76</td>
</tr>
<tr>
<td>1st 100um</td>
<td>82.00</td>
<td>90.00</td>
</tr>
<tr>
<td>2nd 100um</td>
<td>80.90</td>
<td>105.50</td>
</tr>
<tr>
<td>100 um cantilever</td>
<td>82.49</td>
<td>71.38</td>
</tr>
</tbody>
</table>

Height

Note: Used Dectak for results.

Sample 1 (in A)

<table>
<thead>
<tr>
<th></th>
<th>1st Measurement</th>
<th>2nd Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2932</td>
<td>2703</td>
<td>2926</td>
</tr>
<tr>
<td>2906</td>
<td>2893</td>
<td>2801</td>
</tr>
</tbody>
</table>

Sample 2 (in A)

<table>
<thead>
<tr>
<th></th>
<th>1st Measurement</th>
<th>2nd Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>3136</td>
<td>3218</td>
<td>3166</td>
</tr>
<tr>
<td>3244</td>
<td>3139</td>
<td>3038</td>
</tr>
</tbody>
</table>

50 um wide beam
100 um wide beam

Length Measurements