High School Summer Intern Program
University of California, Berkeley
EECS/ERL

Characterization of Boron Diffusion from Boron+ Source Wafers
Summer 2003
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Outline

Introduction
  • Why I came to the Microlab

Assignment
  • Cleanliness is Paramount

Project
  • Objective
  • Experimental
  • Analysis
  • Conclusion

What I have learned

Acknowledgements
Why I came to the Microlab

• My last summer to do something impressive
• Nothing seemed interesting
• Mom happened upon website
• Denied at first
• Visited Microlab
• Good opportunity to learn about engineering
Cleanliness is Paramount

• Hundreds of steps to complete one design
• At micron level, fabricated devices can malfunction from dirt and organics
• Many precautions are therefore taken to insure cleanliness
  • Lab members must gown-up
  • Adhesive mats are placed through-out lab
  • Lab surfaces must stay clean
  • Air is constantly filtered
  • De-ionized water used
Characterization Of Boron Diffusion From Boron+ Source Wafers
Theory

Diffusion Theory

• Method used to introduce impurities into silicon

Applications

• Etch stop for MEMS
• Junction formation for devices
Experimental

I. Sample Preparation

II. Boron+ Diffusion

III. Oxide Removal and Measurements

IV. Measurement Summary
Sample Preparation

I. Check out 25, 4" N-type test wafers

II. Scribe: 1-25

III. Clean:

- \( \text{H}_2\text{SO}_4 + \text{H}_2\text{O}_2 \) for 10 minutes
- Rise for 5 minutes
- 10:1 \( \text{H}_2\text{O}:\text{HF} \) dip for 30 seconds
- Rinse for 5 minutes
Boron+ Diffusion

I. Load recipe in furnace computer for Tystar14

II. Open furnace, load wafers into boat: back-to-back, facing source wafers (white ceramic)

III. Start program; run for determined time

IV. Unload wafers
Oxide Removal and Measurements

I. Oxidize in steam for 30 minutes at 900°C in Tystar3 to dilute boron glass

II. Measure oxide (glass) thickness using Nanospec

III. Remove glass:

Dip in 5:1 H_2O:HF for 30 seconds
Rinse
Repeat 3 times

IV. Measure sheet resistivity on 4-point probe
# Measurement Summary

## Oxide Thickness (Å)

<table>
<thead>
<tr>
<th>Dope Time (hrs)</th>
<th>WP 1</th>
<th>WP 2</th>
<th>WP 3</th>
<th>WP 4</th>
<th>Average</th>
<th>non-Unif.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3663</td>
<td>4034</td>
<td>3504</td>
<td>3222</td>
<td>3606</td>
<td>22.54%</td>
</tr>
<tr>
<td>4</td>
<td>5915</td>
<td>6609</td>
<td>5592</td>
<td>4960</td>
<td>5769</td>
<td>28.58%</td>
</tr>
<tr>
<td>8</td>
<td>6877</td>
<td>7620</td>
<td>6448</td>
<td>5853</td>
<td>6700</td>
<td>26.38%</td>
</tr>
<tr>
<td>16</td>
<td>16355</td>
<td>20170</td>
<td>16008</td>
<td>14341</td>
<td>16718</td>
<td>34.87%</td>
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</tbody>
</table>

## Sheet Resistance (ohm/square)

<table>
<thead>
<tr>
<th>Dope Time (hrs)</th>
<th>WP 1</th>
<th>WP 2</th>
<th>WP 3</th>
<th>WP 4</th>
<th>Average</th>
<th>non-Unif.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2.664</td>
<td>2.734</td>
<td>2.700</td>
<td>2.660</td>
<td>2.690</td>
<td>2.75%</td>
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<tr>
<td>4</td>
<td>1.921</td>
<td>1.968</td>
<td>1.955</td>
<td>1.936</td>
<td>1.945</td>
<td>2.41%</td>
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<tr>
<td>8</td>
<td>1.556</td>
<td>1.593</td>
<td>1.587</td>
<td>1.571</td>
<td>1.577</td>
<td>2.33%</td>
</tr>
<tr>
<td>16</td>
<td>1.000</td>
<td>1.038</td>
<td>1.021</td>
<td>1.058</td>
<td>1.029</td>
<td>5.67%</td>
</tr>
</tbody>
</table>
Tystar14 Oxide Thickness Chart

Oxide Thickness (Å) vs. Dope Time (hrs)

Non-Uniformity

WP 1
WP 2
WP 3
WP 4
Average
non-Unif.

Microlab
Conclusion

Our results indicate:

• Growth of oxide thickness will increase with dope time

• Resistivity decreases as time elapses (Less voltage is required to run device as the concentration of dopant increases)

• Sheet resistance does not change linearly with diffusion time (If wafer stayed in twice as long, resistance will not be twice as low
What I Have Learned

• Wafer fabrication is a costly and tedious job, requiring hundreds of steps, where the wafers are easily susceptible to contamination

• The importance of lab cleanliness is imperative, though often overlooked

• Doping can change the conductivity and resistivity of a wafer

~Photolithography~

When transferring a pattern from a mask to the wafers’ surface, the amount of energy from the u.v. light determines how much photoresist will be removed.
Acknowledgements

Marilyn Kushner for taking me throughout the lab and showing me the importance of lab cleanliness

Jimmy Chang, this project would still be a foreign language if it were not for your knowledge, patience, and guidance

Kim Chan for teaching me the basics of photolithography

Katalin Voros for giving me the ultimate Microlab experience – lab coat included!

Mom- thanks for pushing me to take an opportunity such as this one