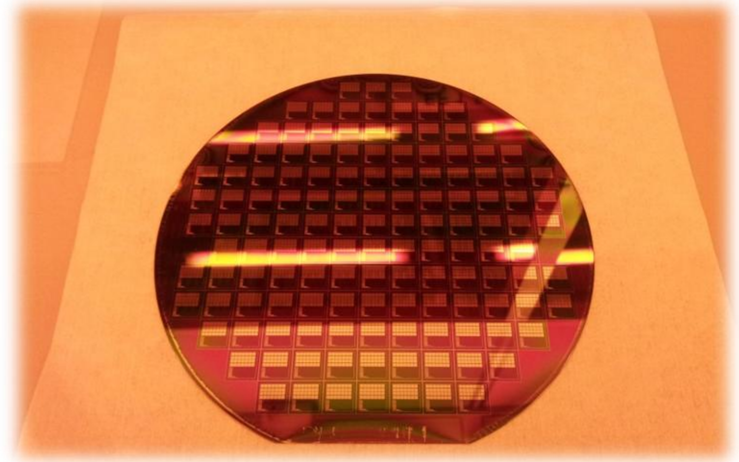


2012 Marvell NanoLab Summer Internship

Wendy Li
Albany High School

Overview

- Project Objective
- Background context
  - Metal Evaporation
  - Mask Design
- Processing and Data
  - Initial Measurements
  - Photolithography and Tystar furnaces
  - Wafer layers
  - Measurements and Results
- Metal Deposition
  - Process Description
  - Lift Off Process
- Results
  - Resistivity and Reflectance
  - Contact Resistance
- Conclusion
- Acknowledgements

Project Objective

1. Qualify CHA metal deposition through measuring contact resistance, sheet resistance and reflectance.
2. Create test wafers for measuring the contact resistance of certain metals deposited by the CHA

How Does Metal Evaporation Work?

Substrate heater

Evaporation flows

Substrate
(Crystal、Glass、
Resin、metal)

Evaporation
thin film

A vacuum less
than 1.0E-3Pa

Vacuum pump

e-Beam

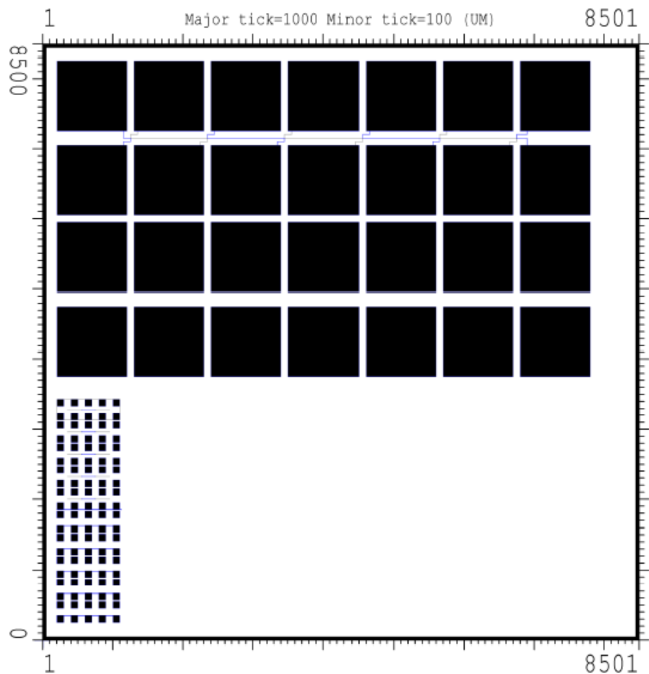
Evaporation
materials
(metal・
dielectric)

Electron
beam sources

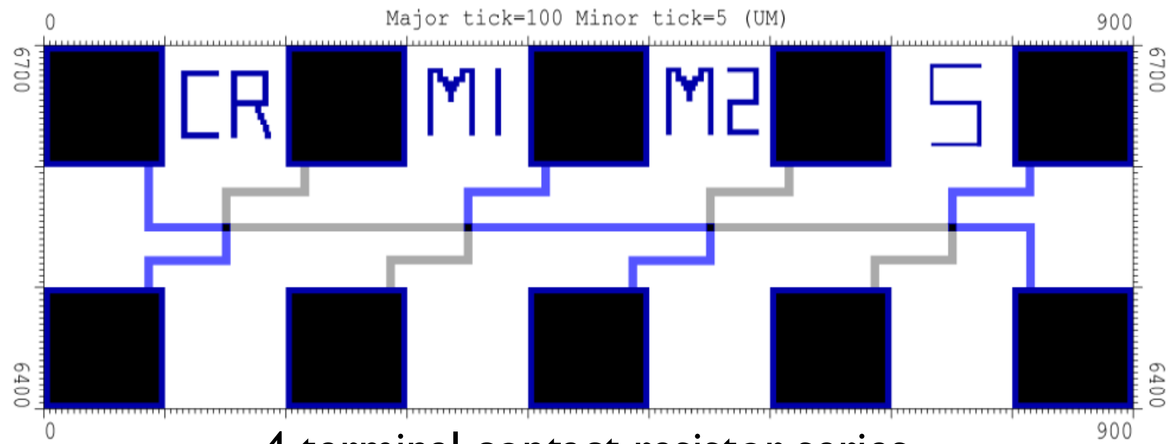
Crucible

Evaporation equipment

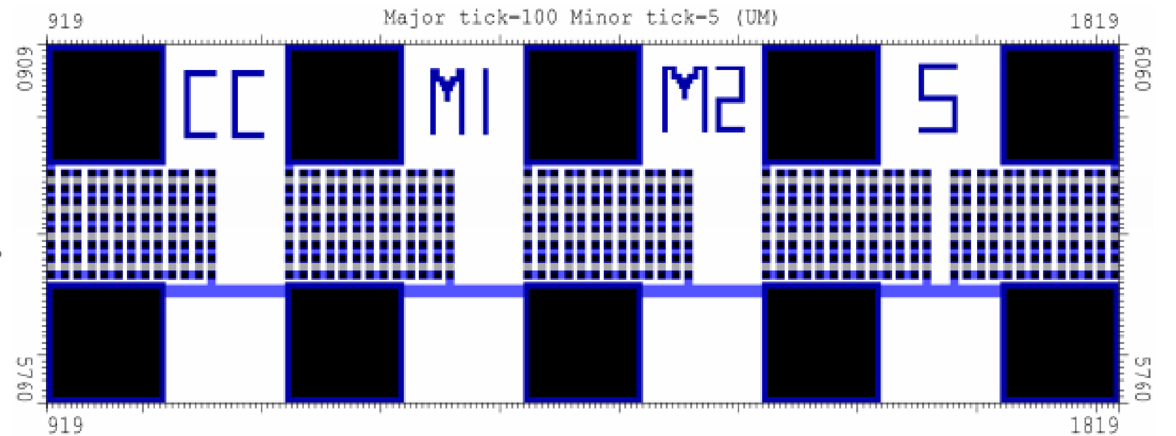
Mask Design



Die design



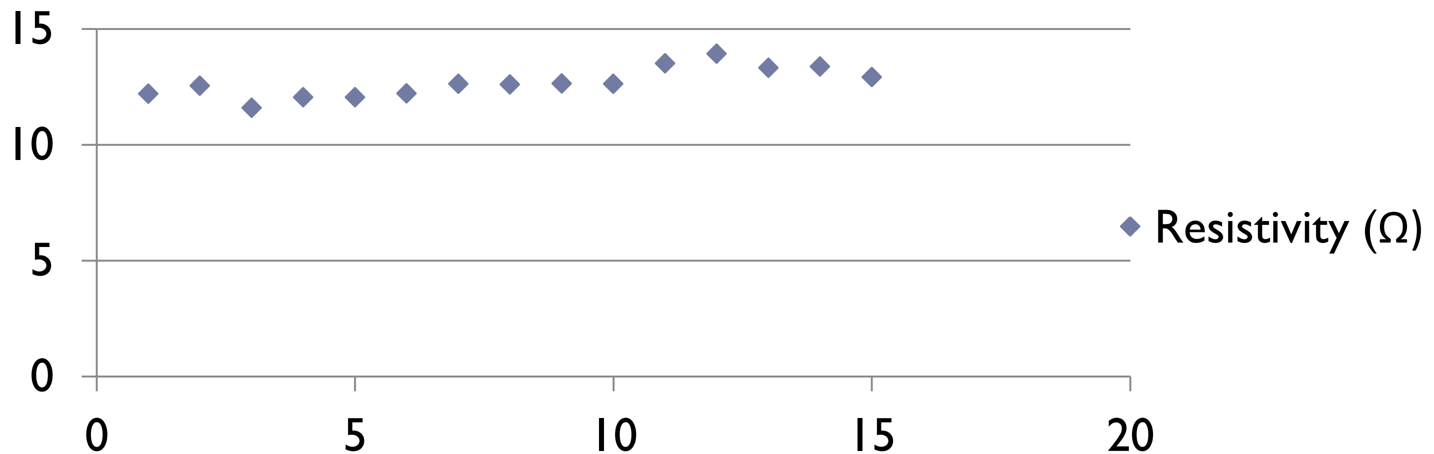
4 terminal contact resistor series



Via chain contact resistors (104 vias)

Part A: Creating the Test Wafers

Initial Measurements



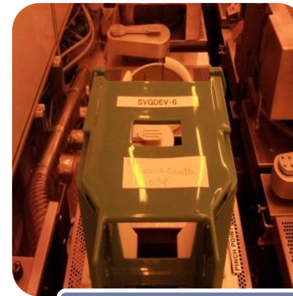
Total average resistivity: 12.714 Ω

Resistance of N-doped poly: 6.357 µΩ- meters

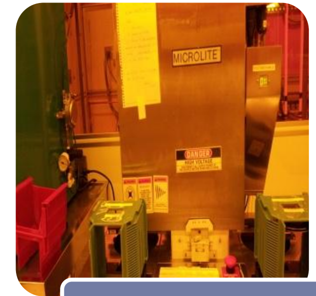
Process: Photolithography and Etching

svgcoat6

asml300



svgdev6



uvbake

etch machine

matrix photoresist stripper

msink8

Process: Tystar Furnace

msinks

drier

tystar

Wafer Layers

Metal layer

1 micron low temperature oxide

0.5 micron n-doped poly-silicon

1 micron thermal oxide

Silicon wafer

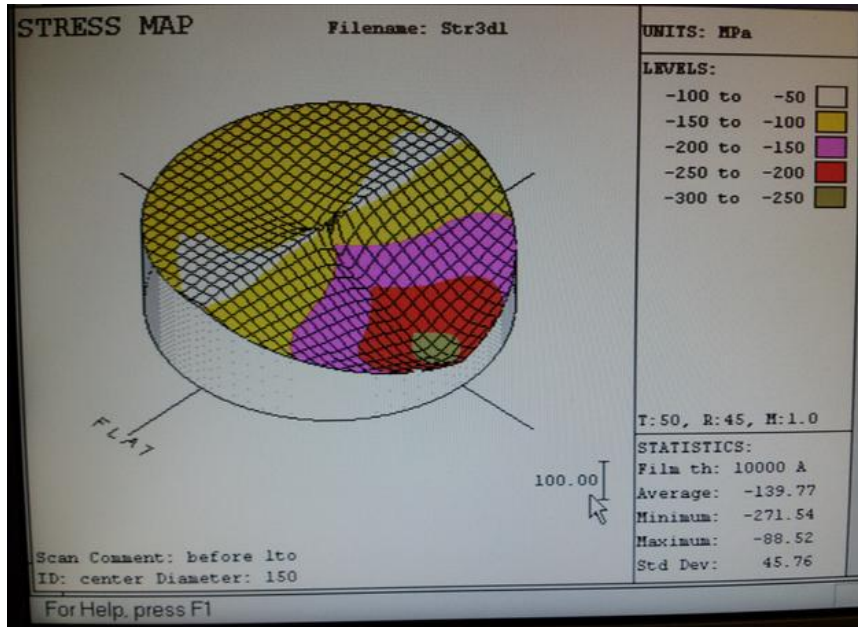
Data: Oxide Deposition Rate of Tystar12

Angstroms (Å)	Load	Center	Pump
C	7060	6908	6598
T	7180	6955	6671
F	7054	6862	6629
L	7039	6973	6627
R	7150	6775	6597

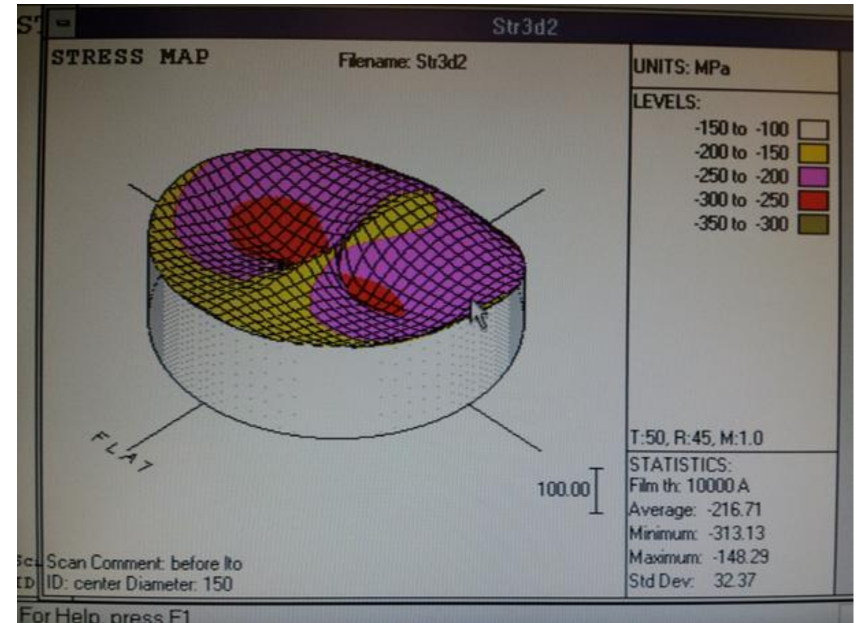
Rates of Deposition
Load: 7096.6 Å/ hour
Center: 6934.6 Å/ hour
Pump: 6624.4 Å/ hour
Total: 6885 Å/ hour
For 1 micron of oxide, deposition time is 87.145 minutes

Angstrom (Å)	After Oxide Growth	After Annealing
C	10133	9889
T	10369	10119
F	10058	9811
L	10156	9903
R	10205	9954
Average	10184.2	9935.2

Data: Stress Testing



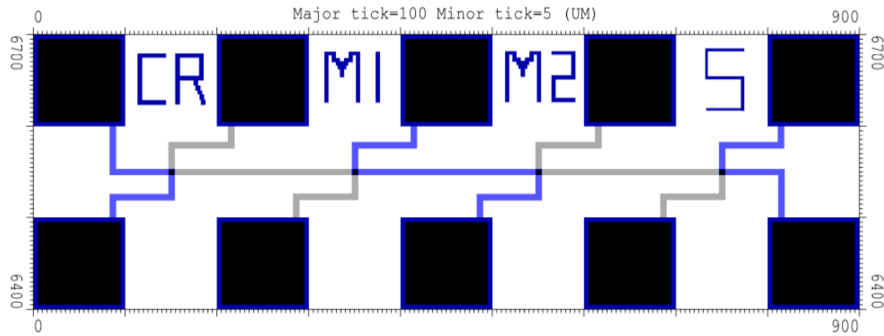
Before Anneal

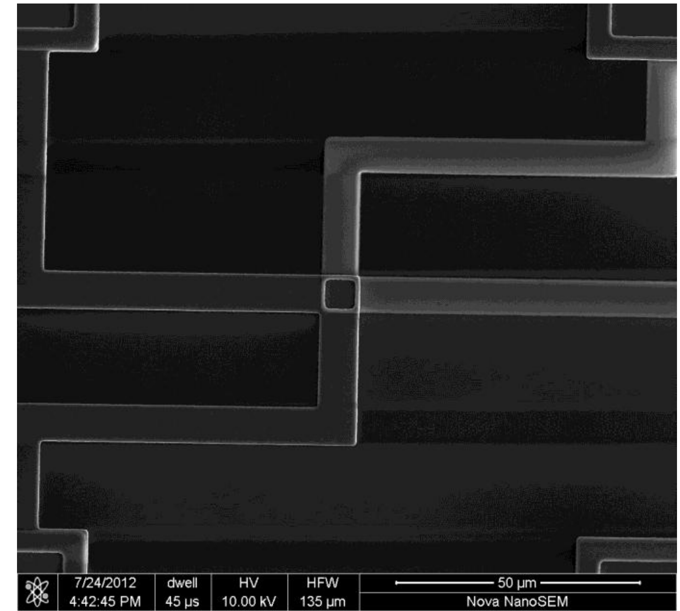


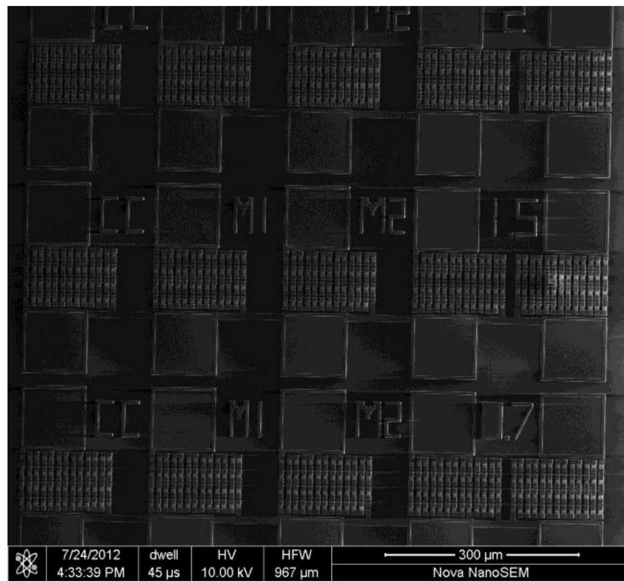
After Anneal

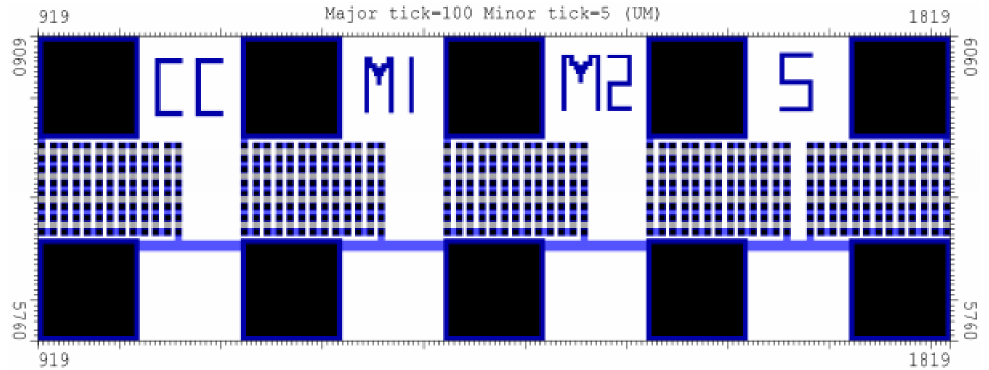
- 0 degrees: stress 228.6 Mpa
- 90 degrees : stress 230.9 Mpa

Fabrication Structures

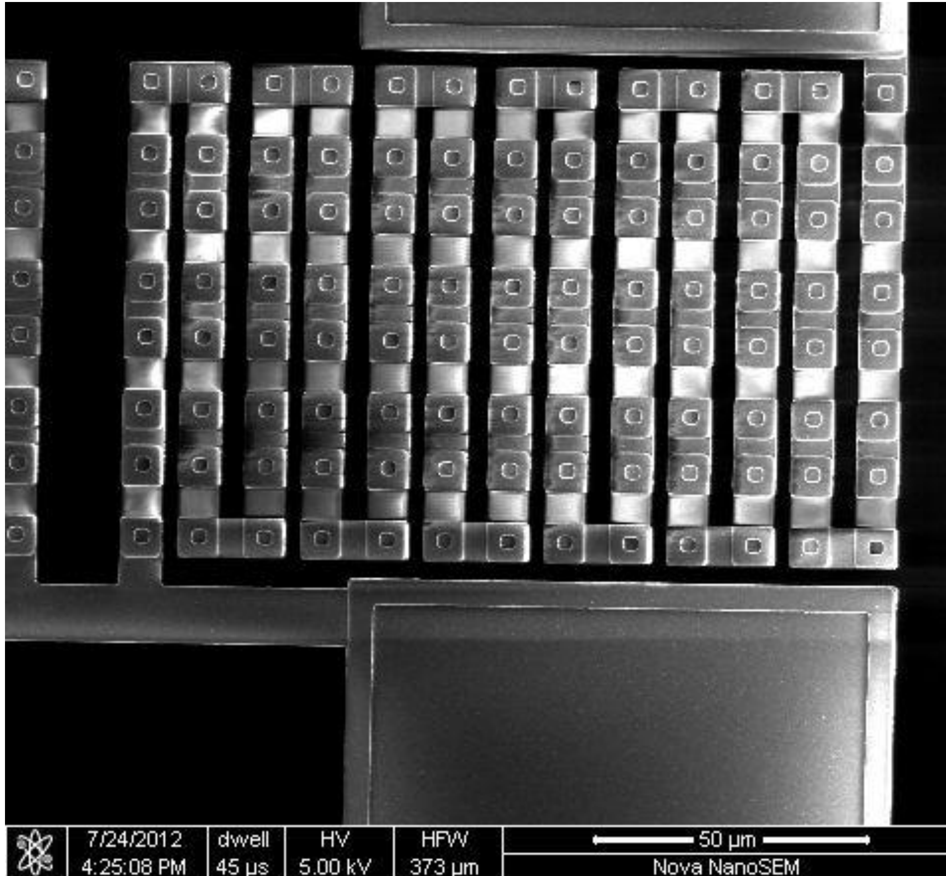


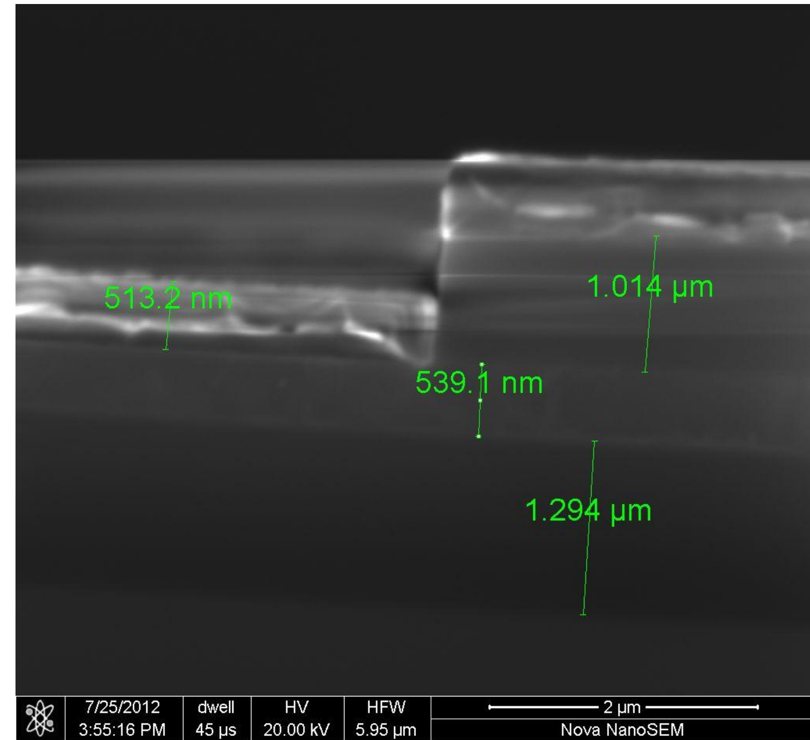




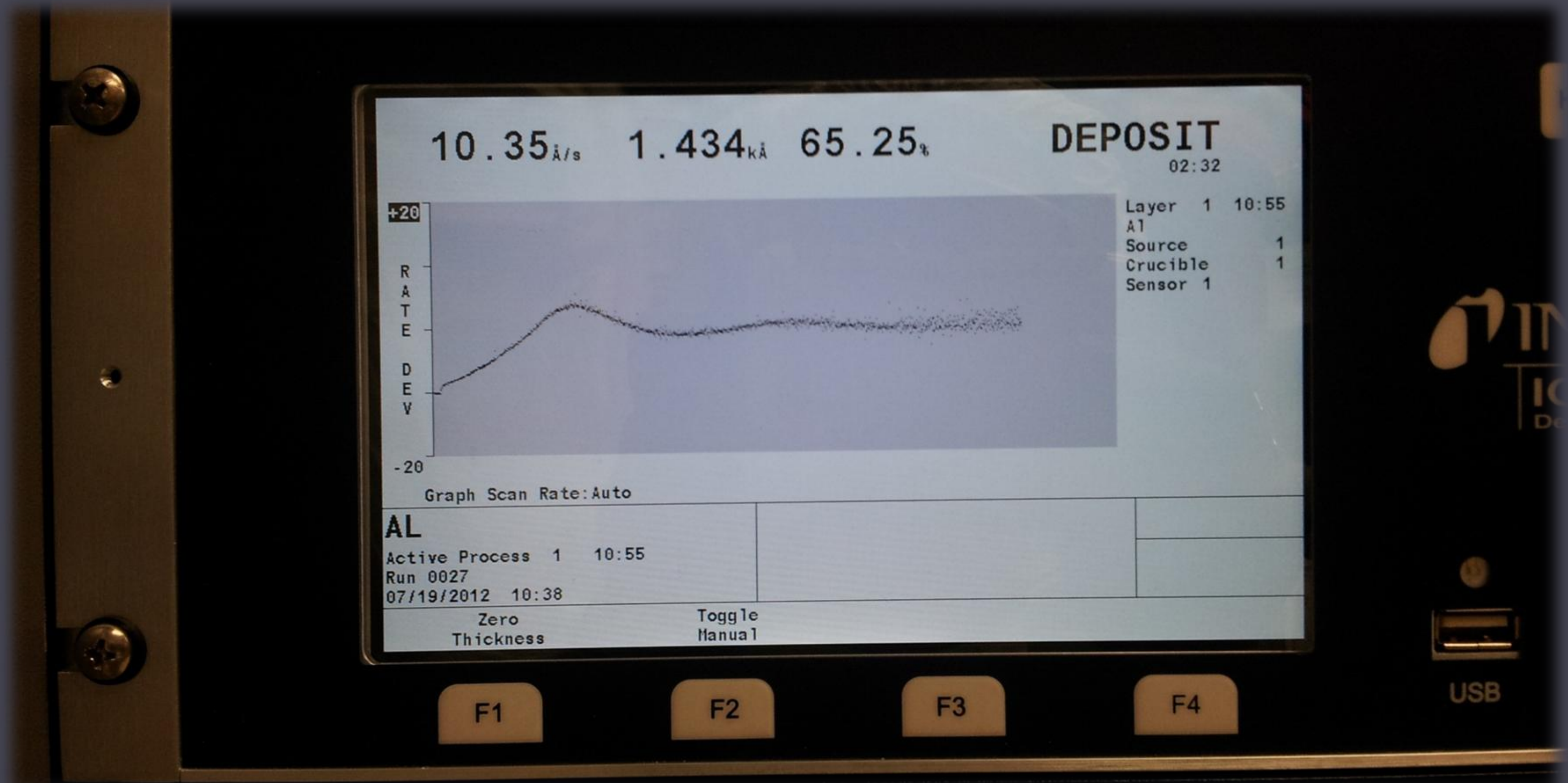


Fabrication Structures and Deposition Thickness



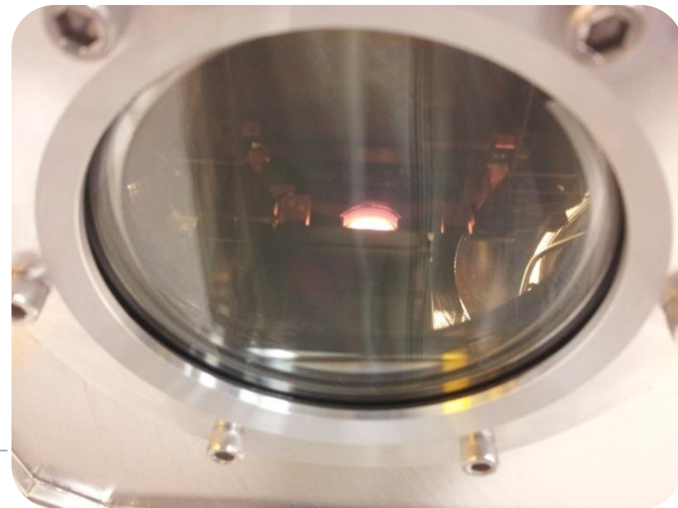


Part B: Metal Deposition and Data Collection



Process: Metal Deposition

1. Vent CHA and load 1 blanket oxide, 1 liftoff, and 1 normal etch wafer.
2. Pump down CHA until it is at least 9 x 10^-7 torr.
3. Load recipe for metal deposition and run.
4. After deposition is complete, wait for metal to cool and vent.
5. Take out wafers and etch or liftoff metal.



Lift Off Process

1. Before metal deposition coat the wafer, expose, and develop for the lift off pattern.
2. After metal deposition, place wafer in a bath of acetone and let sit for 2 hours.
3. Remove any metal still remaining and clean wafer with IPA then water.

Data: Aluminum Resistivity and Reflectance

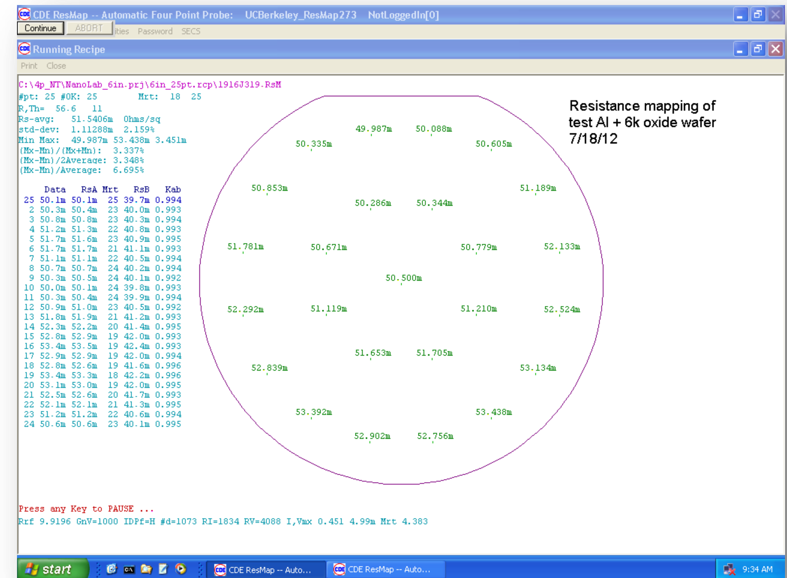
CDE Res Map Results:

Average resistivity of 51.5406 mΩ/sq

Aluminum resistance of 28.23 nΩ-m

Reflectance Results:

	436 nm	640 nm	280 nm
C	202.41%	258.78%	262.77%
T	203.58%	258.41%	261.91%
F	201.71%	259.19%	263.22%
L	203.15%	257.86%	261.52%
R	200.72%	250.67%	252.59%



Data: Titanium Resistivity and Reflectance

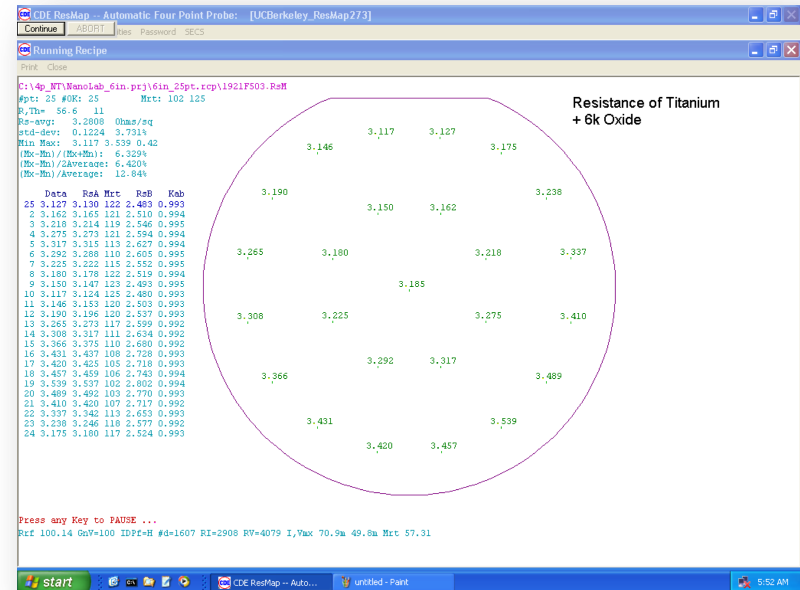
CDE Res Map Results

Average Resistivity of 3.2808 Ω/sq

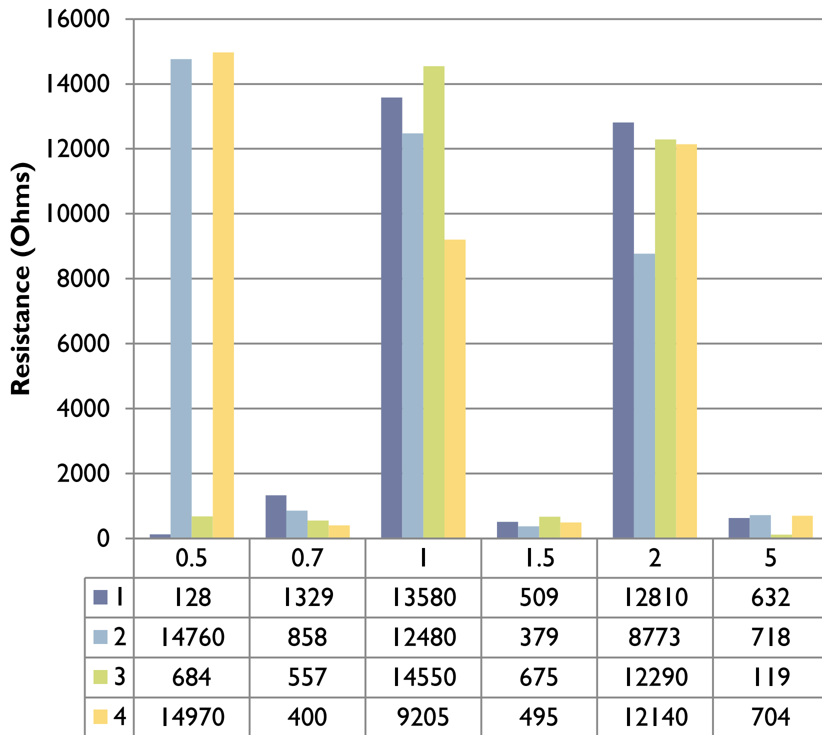
Volume Resistance of 678.9 nΩ-m

Reflectance Results

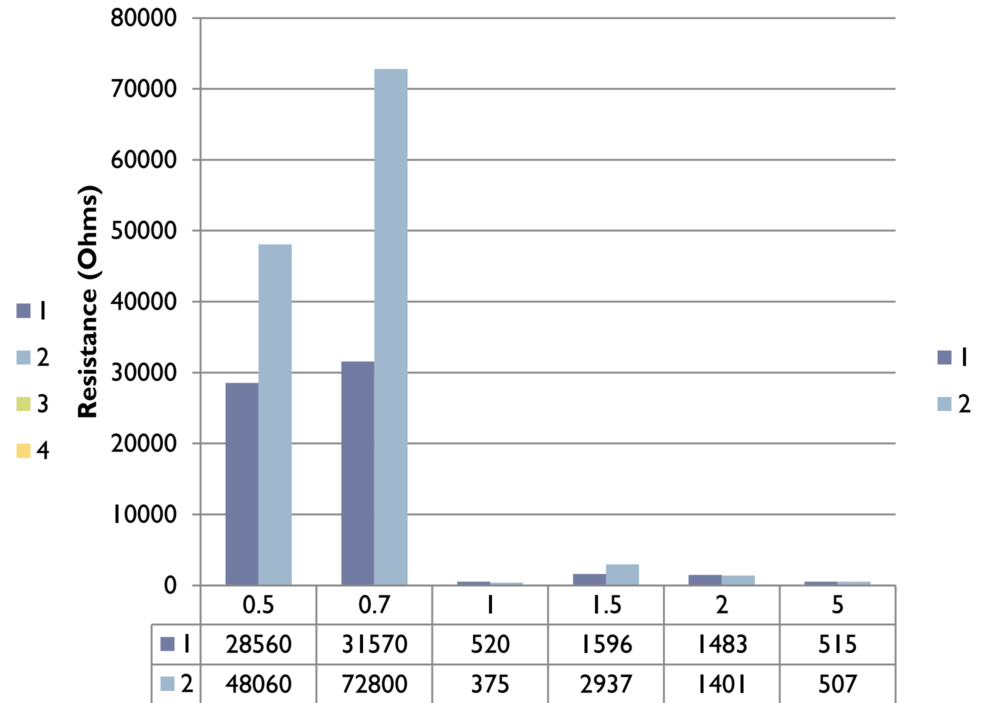
	436 nm	640 nm	280 nm
T	113.50%	164.63%	174.34%
C	112.86%	164.15%	174.03%
F	111.88%	165.71%	176.62%
L	113.53%	165.03%	174.52%
R	112.1%	164.90%	175.21%



Data: Contact Resistance of Single Vias

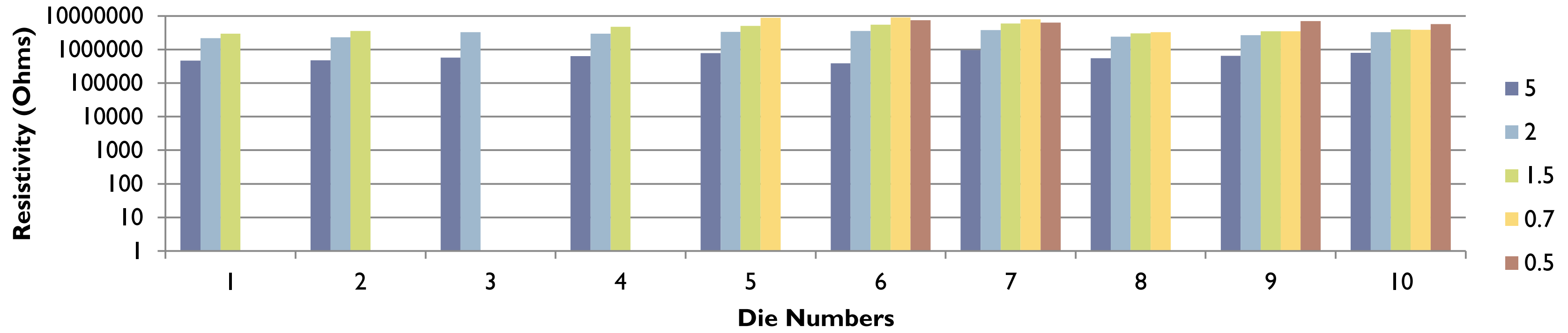


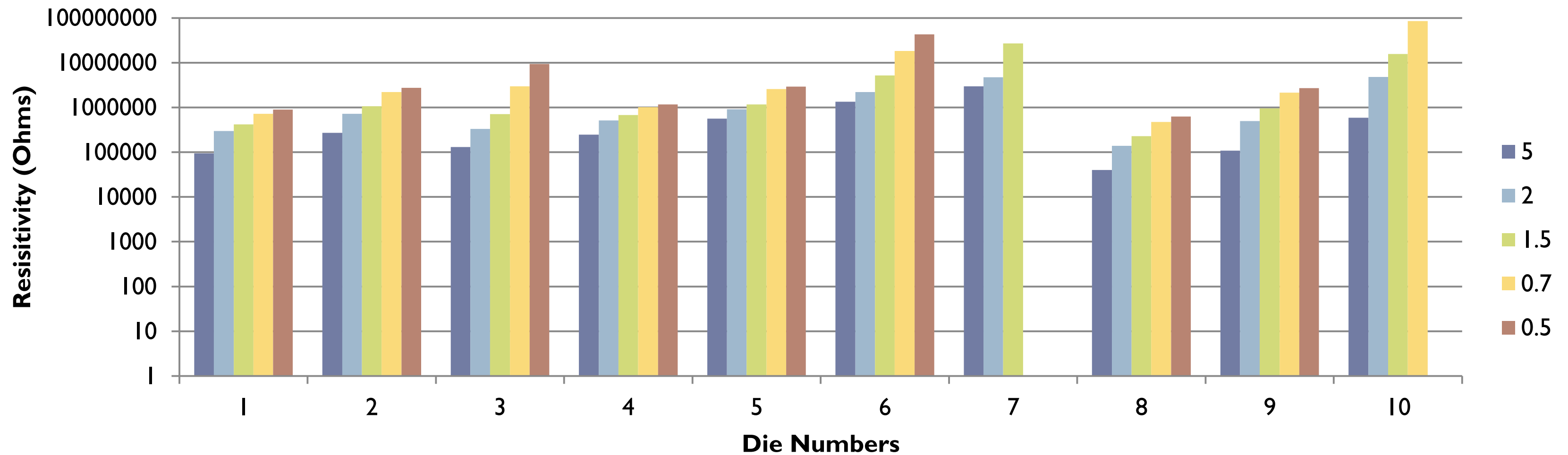
	0.5	0.7	1	1.5	2	5
1	128	1329	13580	509	12810	632
2	14760	858	12480	379	8773	718
3	684	557	14550	675	12290	119
4	14970	400	9205	495	12140	704



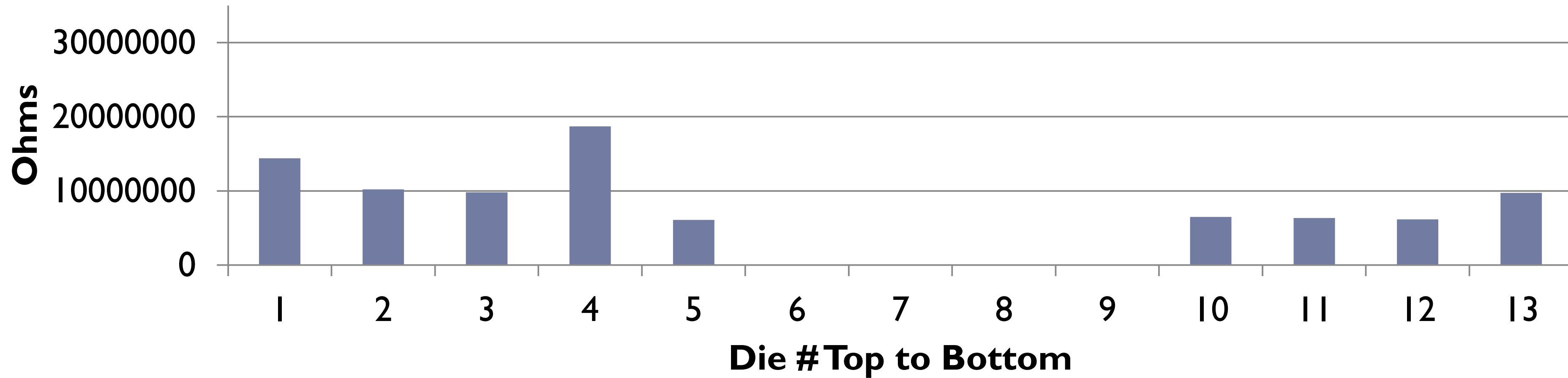
	0.5	0.7	1	1.5	2	5
1	28560	31570	520	1596	1483	515
2	48060	72800	375	2937	1401	507

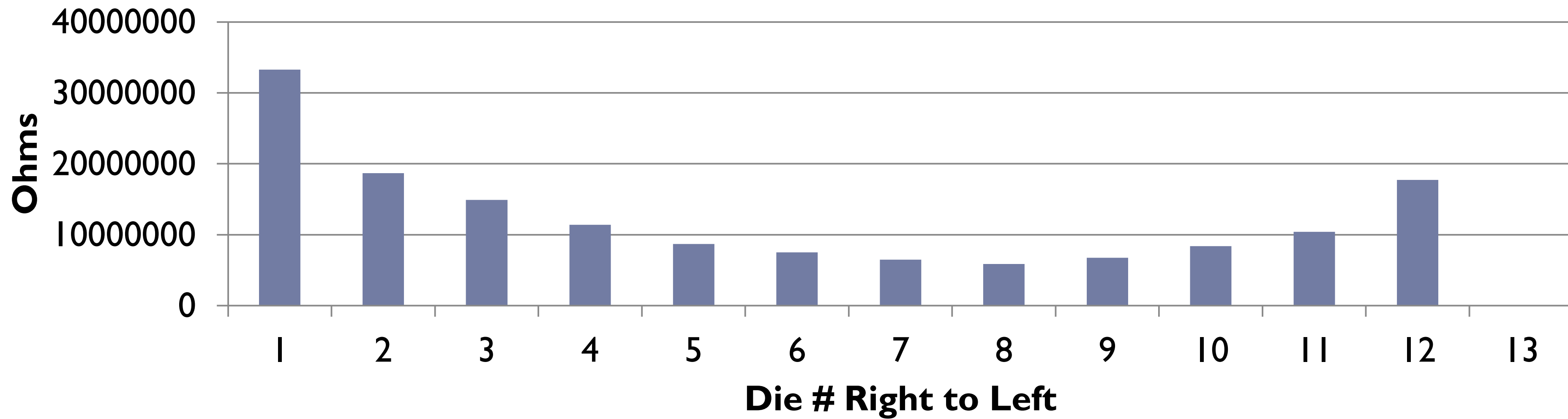
Data: Contact Resistance of Via Chains



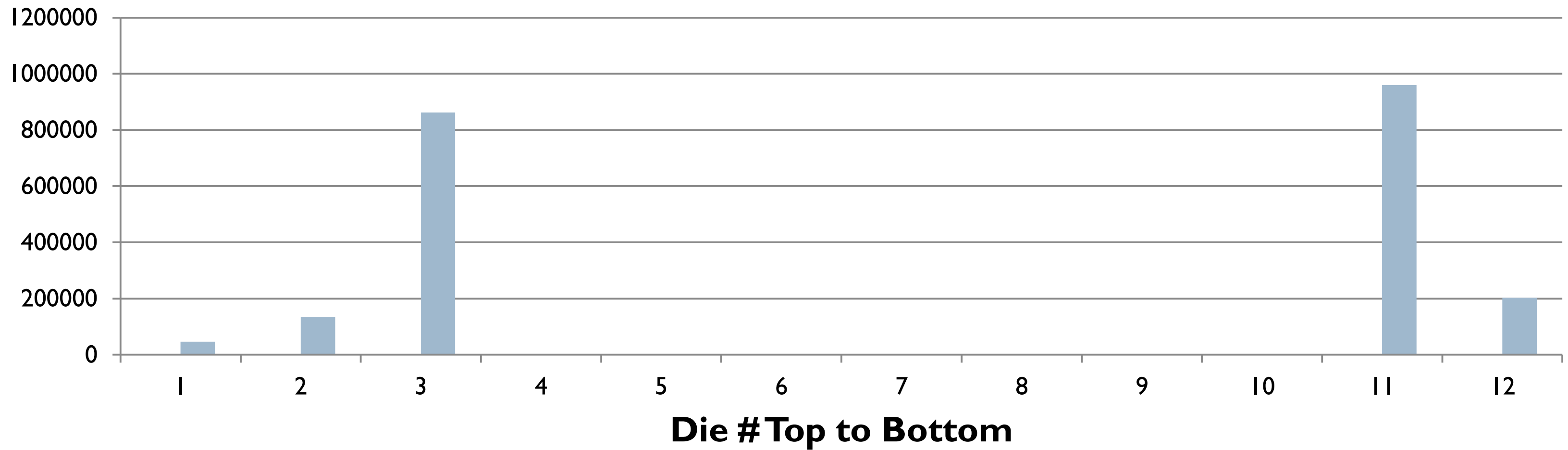


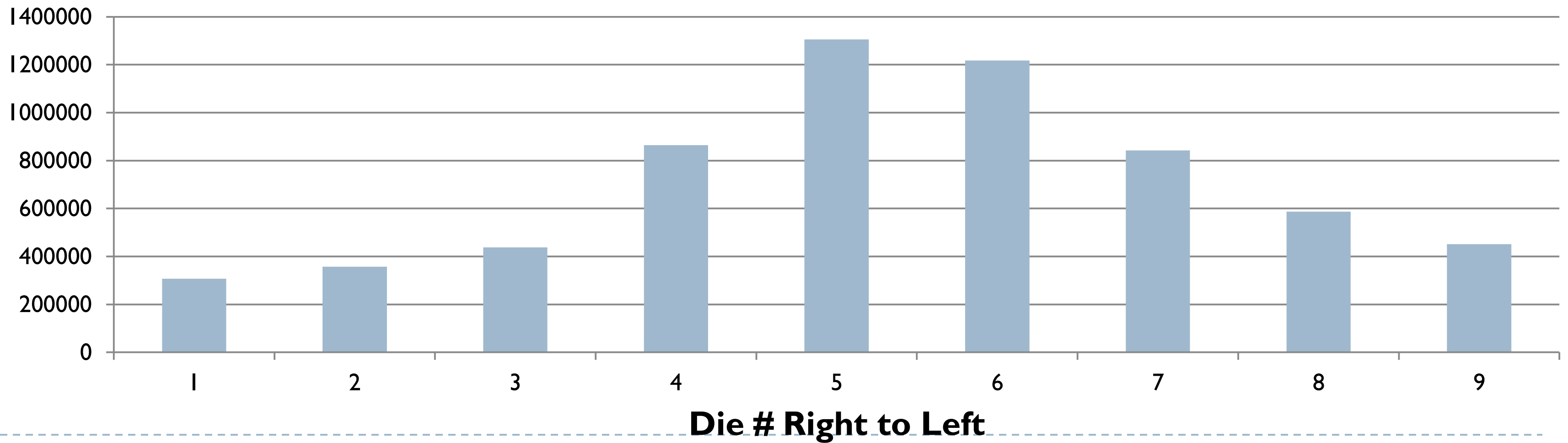
Resistance vs. Position (5µm via chains) of Aluminum Deposition



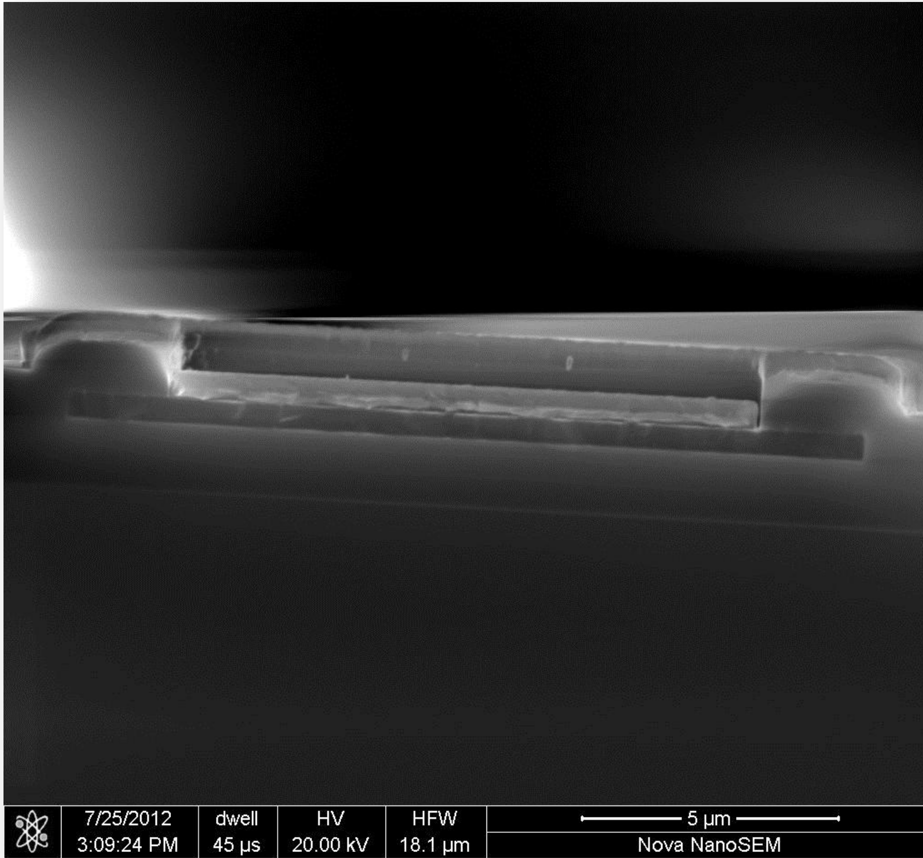


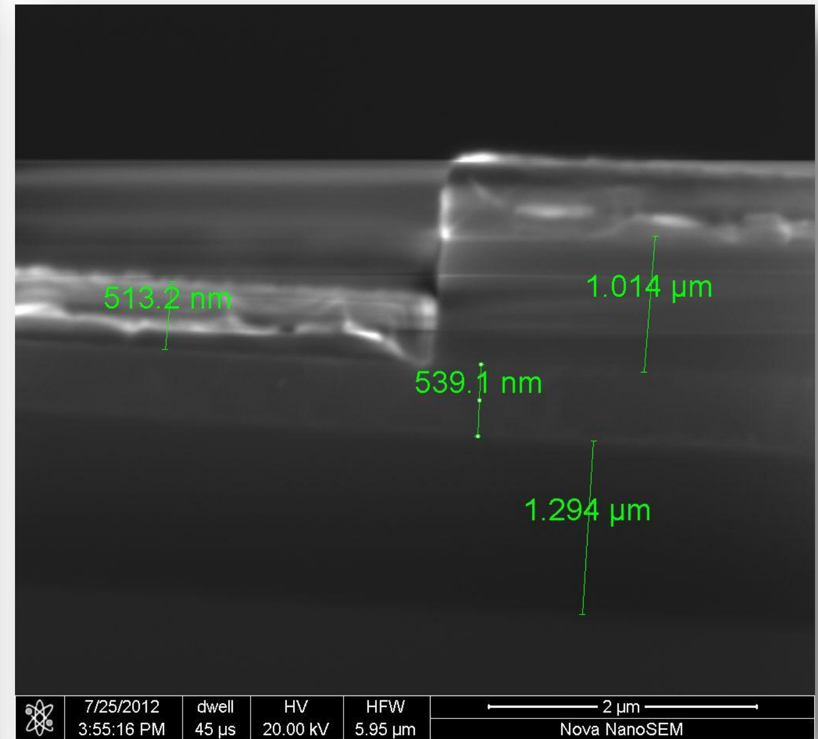
Resistivity vs. Position (5μm via chains) of Titanium Deposition





Analysis





Conclusion

- Contact resistivity varies from the edge to the center of the wafer, indicating uneven sidewall coverage in the via.
- Resistance typically increases as via size decreases. Optimal via sizes for high yield should be within the range of 1.5 to 5 microns to avoid capping the metal.
- It is not recommended to use the CHA for via formation.
- The CHA is also capable of producing high purity metal depositions with low resistance.

Acknowledgements

- Thanks to Marilyn Kushner, Sia Parsa, Kim Chan and Karishma B. for contributing to my project process, without your help, I would not have been able to complete my process.
- Thanks to all of the staff for being willing to take time out of their busy schedules to explain concepts and help me out.
- Thank you Katalin Voros and Bill Flounders for providing this amazing summer opportunity.
- Thanks to all the students and interns who made the experience so much fun!
- Thank you Ryan Rivers for being a wonderful mentor

Thank you