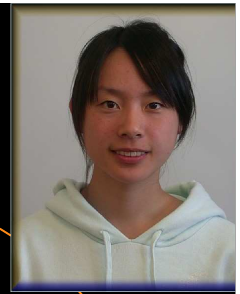


Berkeley Microlab Summer Internship 2007

CPA:
Al Thickness
vs.
Sheet Resistance

Emmeline Lan

Why I came

- Aspire to major in engineering
- Interested in working in high-tech lab
- Good opportunity to learn both academic and social skills

Introduction

- **Project: come up with a quick method to determine Al thickness using resistivity**
- **Why?**
  - **Light cannot pass through Al = no Nanospec**
  - **Deposited Al must be patterned and etched to measure thickness**
  - **Long and tedious process**
  - **4 – point probe is much easier**

How do we do it?

- **Data: Sheet Resistance of Aluminum**
  - Measure the sheet resistance of different thicknesses of aluminum
- **Data: Thickness of Aluminum**
  - Etch away Al to measure exact thickness
- **Formulate efficient Al thickness calculation method**
  - Find relationship between Al thickness and sheet resistance

Procedure

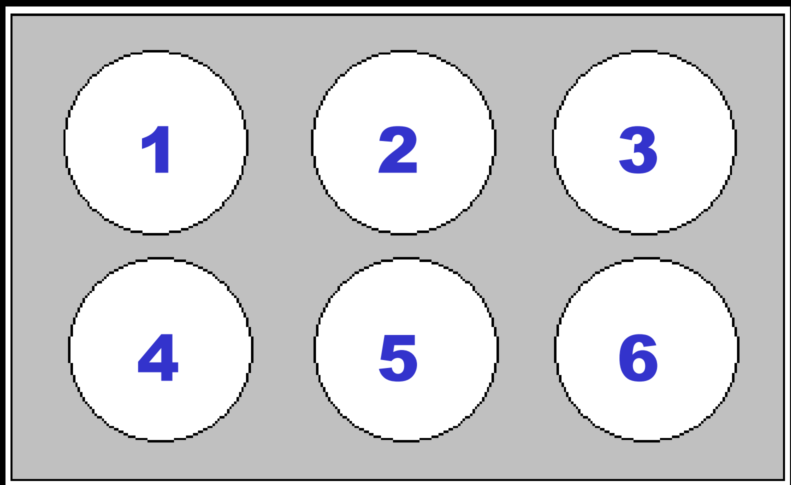
Process

1. Clean wafers (25)
2. Grow oxide w/ wet oxidation
3. Deposit Al

Machinery

Sink 6
Tystar 2

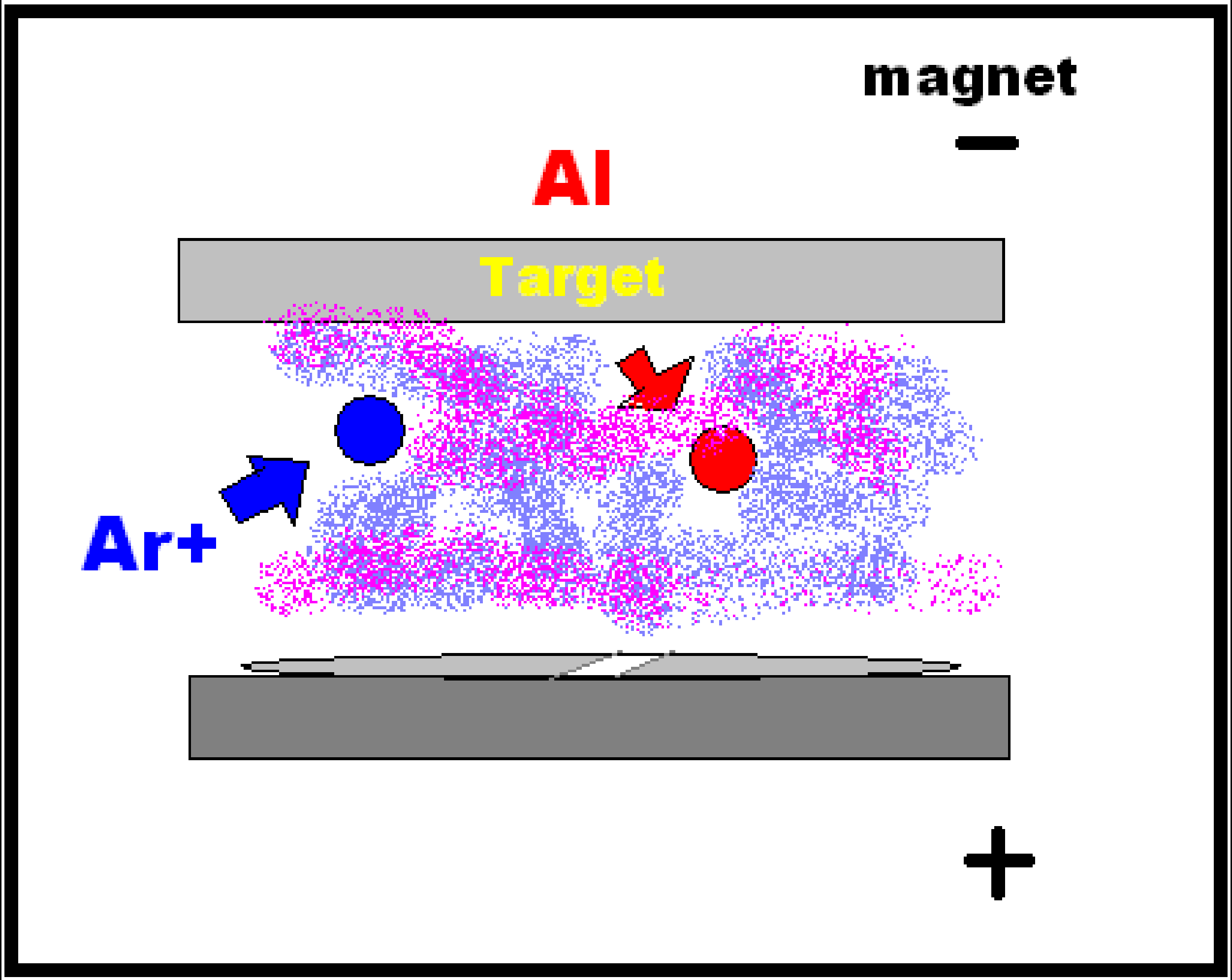
CPA



Sputtering Process

1. Apply high vacuum to rid system of water, oxygen, and other reactive gases
   - Al is very reactive & is likely to react with water to form Al_2O_3
2. Power is applied
   - Negative potential at the Al cathode
   - Positive charge at the anode, direction of wafer
3. Free e- in chamber collide with Ar
   - Knocks off more e- from Ar, forming Ar+
   - Chain reaction strikes glowing, purple plasma
4. Ar+ atoms, attracted to negative potential, hit the Al cathode
5. High energy ions dislocate Al atoms in all directions
6. Al atoms rain onto wafers below, coating them uniformly

Inside the CPA...



Conditions:

-Base pressure:

- 1.8 x 10^{-7} torr (1-12)
- 1.3 x 10^{-7} torr (13-24)

-Ar pressure: 6 x 10^{-3} torr

-Ar flow: 62 cc/min

-Power: 4000 watts

-Track speed: 20.0 cm/min

Procedure (cont…)

Process | Machinery

4. Dry etch Al coat — **LAM 3**

5. Measure sheet resistance — **4-point probe**

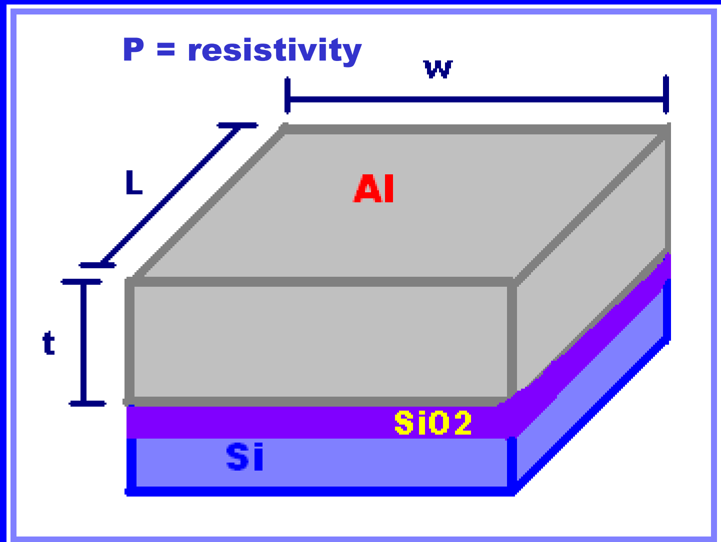
Why do we measure sheet resistance?

$$R = \rho\ (L/A)$$
$$= \rho\ [\ L/\ (wt)\ ]$$
$$= \rho/t \times L/w$$

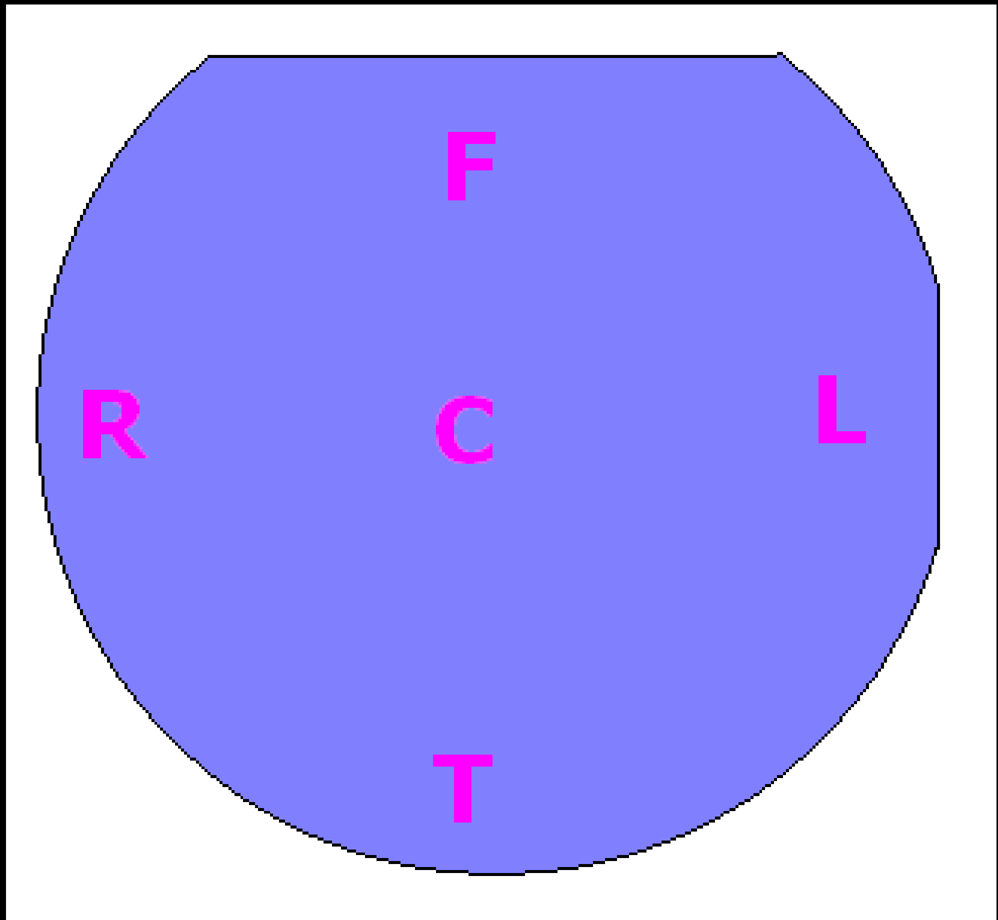
- ρ/t is the sheet resistance (ohm/square), or R_s

$t/\rho = 1/R_s$

$T = \rho/R_s$! We now have an equation with thickness as the dependent variable!



4- point Probe measurements



- typical 5 points: top, flat, left, right, center
- had to approximate locations

Process

6. Pattern wafers
   - Apply photoresist
   - Pattern wafers
   - Develop photoresist
7. Wet etch exposed Al
8. Measure Al step height

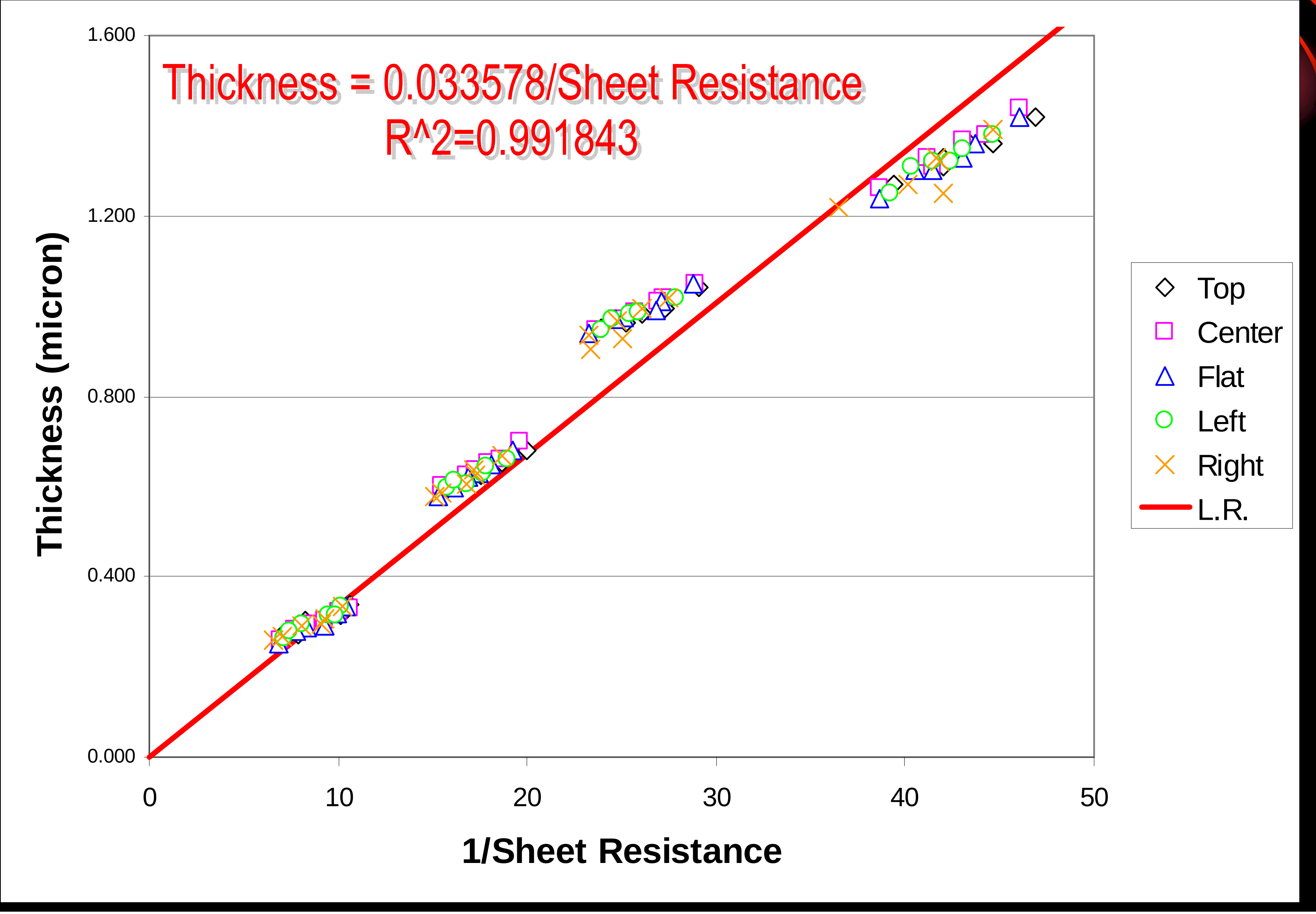
Machinery

SVGcoat1
GCAWS
SVGdev

Sink 9
ASIQ

Results

Al Thickness vs. Sheet Resistance



Wafer #	Avg Thickness	Avg Resistivity	Fit thickness	% error
1	0.294	0.122	0.27618	6.31%
2	0.263	0.143	0.235338	11.67%
3	0.274	0.134	0.249873	9.82%
4	0.334	0.096	0.348826	4.25%
5	0.302	0.107	0.312819	3.46%
6	0.313	0.102	0.329067	4.88%
7	0.635	0.057	0.585799	8.33%
8	0.591	0.064	0.521884	13.17%
9	0.608	0.062	0.54492	11.50%
10	0.679	0.052	0.646975	5.01%
11	0.627	0.058	0.581739	7.85%
12	0.643	0.056	0.602837	6.60%
13	1.006	0.037	0.897328	12.16%
14	0.944	0.042	0.792682	19.14%
15	0.963	0.040	0.836522	15.17%
16	1.036	0.035	0.95392	8.60%
17	0.971	0.040	0.837774	15.95%
18	0.982	0.038	0.885029	10.98%
19	1.342	0.024	1.428851	6.08%
20	1.254	0.026	1.306537	4.02%
21	1.298	0.025	1.34312	3.36%
22	1.410	0.022	1.533242	8.04%
23	1.312	0.024	1.404937	6.62%
24	1.344	0.023	1.45108	7.38%
			Avg % error	8.76%

☺ etched

☻ unetched

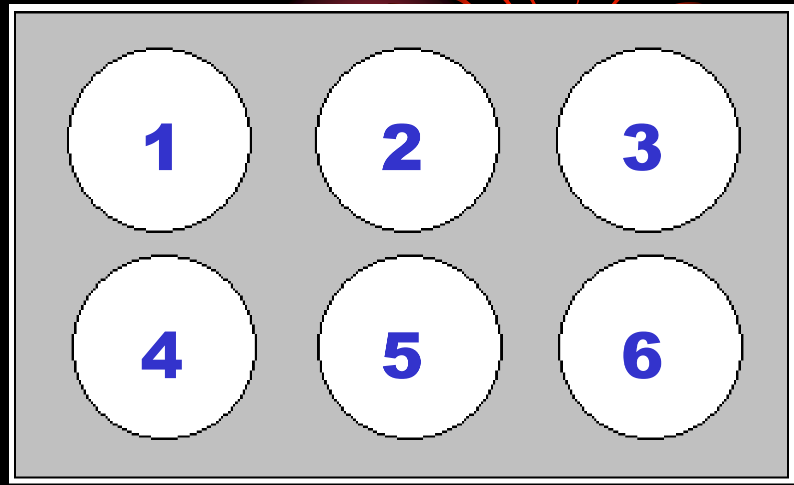
Accuracy

- % error = (data-fit)/fit x 100%
- estimate of thickness from resistivity within 8.76%
- etched wafers are less uniform
  - Lam 3: etch non-uniformity on single wafer is 3 – 12%
  - Wafer to wafer: 19.51%

Calculating resistivity

- ρ = 0.033578 μm x mΩ
  = 3.36 μΩ x cm
- Given resistivity (webelements.com)
  = 2.65 μΩ x cm
- % difference
  - [(3.36 – 2.65)/ 2.65] x 100% = 26.8%
- Higher Resistivity may be due to:
  - contaminated Al during sputtering or dirty particles during etch
  - Based on graph, fit overestimates actual resistivity
  - Al structure changes during sputtering due to high energy impact

Wafer #	Average thickness	Non-Unif.
1	0.294	5.44%
2	0.263	7.61%
3	0.274	8.38%
4	0.334	2.40%
5	0.304	7.57%
6	0.313	7.99%
7	0.635	7.09%
8	0.591	4.06%
9	0.608	8.06%
10	0.677	5.90%
11	0.627	2.07%
12	0.643	8.56%
13	1.006	3.38%
14	0.944	1.91%
15	0.963	8.62%
16	1.036	2.90%
17	0.971	1.75%
18	0.982	8.25%
19	1.342	3.73%
20	1.254	2.39%
21	1.298	8.47%
22	1.410	4.26%
23	1.312	1.52%
24	1.344	8.18%



Uniformity of thickness…

- Is least for the right position on the pallet
- Is best in the middle pallet position
- Is slightly less when etched
- Also, Al is thickest on the left position

etched

unetched

Conclusion

- Measuring sheet resistance is a valid way of estimating thickness
- Thickness = 0.033578/sheet resistance
  - Accuracy: within 8.76%
- Wafers placed in center of pallet have best uniformity
- Wafers on the right have least uniformity
- Try to avoid etch; control thickness in CPA

Acknowledgements

- Katalin Voros for allowing me this great opportunity
- Marilyn Kushner for introducing the stepper and taking us to Semicon
- Daniel Queen for assisting me on the powerpoint
- Jimmy Chang for being a patient and understanding mentor, and making C-MOS processing understandable ☺
- Microlab staff and lab assistants for being friendly and tolerant, and allowing me the honor of accessing their territory