UC BERKELEY MICROFABRICATION LAB INTERNSHIP

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Comparison of Thin-Film Aluminum Deposition

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OBJECTIVE

To compare thin-film aluminum deposition using:

1) Resistivity

2) Uniformity

3) Deposition Rate

OUTLINE OF PROJECT

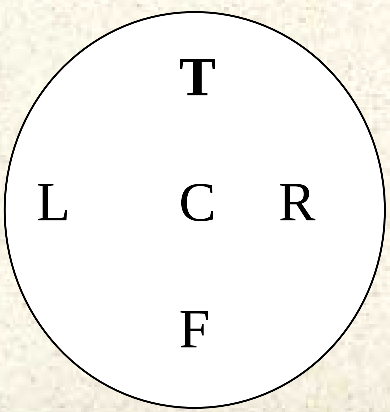
- Cleaning Wafers & Oxide Growth
- Sputtering
  - Novellus m2i Sputtering System
  - Edwards Auto 306DC and RF Sputter Coater
  - CPA Sputtering System
- Evaporating
  - NRC Evaporator
  - Veeco 401 Vaccum System
  - Edwards eb3 Electron Beam Evaporator
- Photolithography & Etching

MEASUREMENT TOOLS & METHOD

NANO SPEC
- thickness of oxide
- reflectance

ASIQ
-step measurement

4 POINT PROBE
- resistivity



- systematic measurement of top, center, flat, left, right

CLEANING WAFERS & OXIDE GROWTH

Sink 6

- Piranha (Sulfuric Acid) with H_2O_2
  - strong oxidizer- removes organic contamination
- Creates some SiO_2

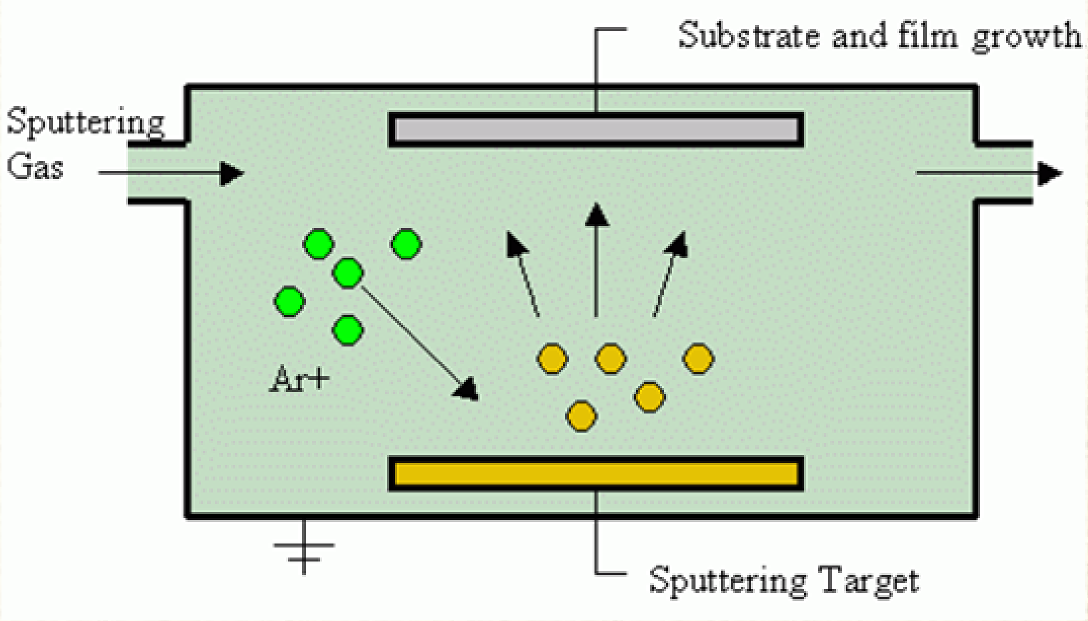
- HF- dissolves SiO_2
  - remove metallic contamination

Tystar 3

-Recipe: 3WETOX
-Temperature: 1000°C
-Time: 10 min 30 sec

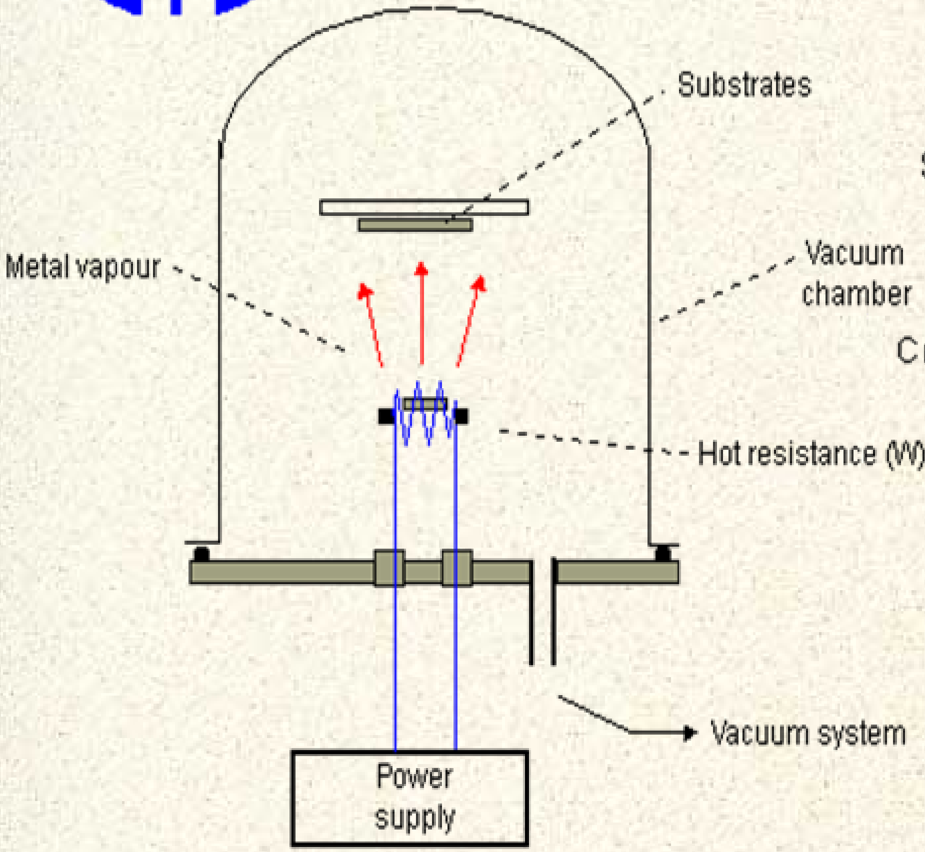
- Steam to oxidize Si → faster than when dry

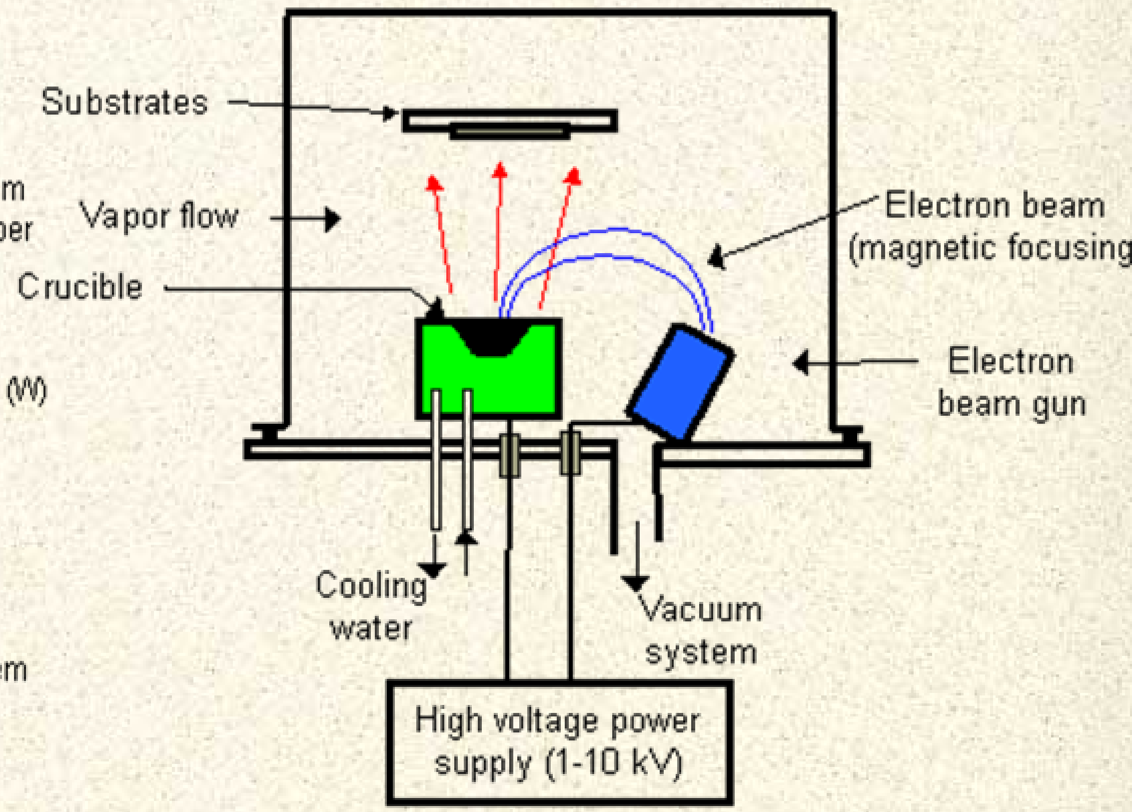
SPUTTERING



Plasma (Argon gas) is ejected into the sputtering target, which releases clusters of aluminum particles onto the substrate (wafer).

EVAPORATING





Metal is heated on through a filament, crucible, or metal plate. The evaporated metal is, then, condensed onto the substrate or wafer.

For an electron beam evaporator, an electron beam bombards the metal which evaporates onto the substrate or wafer.

COMPARISON OF SPUTTERING AND EVAPORATING

	Advantages	Disadvantages
Evaporating	• consumes an efficient amount of aluminum • more cost efficient (little Al per use) • versitile in ability to change metals	• time comsuming
Sputtering	• quick aluminum deposition	• large machine (space is necessary) • expensive aluminum sheet for large target • difficult to change metal

DATA ANALYSIS

Wafer	Non-Uniformity (%)	Bulk Resistivity (Ω-cm)	Overall Time (Hr)	Deposition Rate (Å/min)
Novellus (25)	13.45	0.0414392	1/6	279.6
Novellus (26)	11.06	0.02634984	1/6	550
Edwards (13)	10.84	0.1126076	4	53.44
CPA (2)	1.1	0.03399536	4	N/A
NRC (5)	9.48	0.7033494	2	242.47
V401 (12)	12.39	0.184477	2	251.8
Edwards eb3 (31)	21.95	0.06602736	4	150

- Non-Uniformity= (max-min)/avg
- Bulk Resistivity= resistivity*thickness

DATA ANALYSIS

Wafer	Pre-thickness of Oxide	Post-thickness of Oxide	Reflectance at 640 nm (% relative to Si)
Novellus (25)	1084.4	1029.2	244.8
Novellus (26)	1218.4	1041.8	226
Edwards (13)	984.8	1007.6	217.2
CPA (2)	999.4	1432.8	234.4
NRC (5)	1001.4	1002.4	160.4
V401 (12)	1004.8	1004.8	212.2
Edwards eb3 (31)	1237.4	1193	196

OBSTACLES

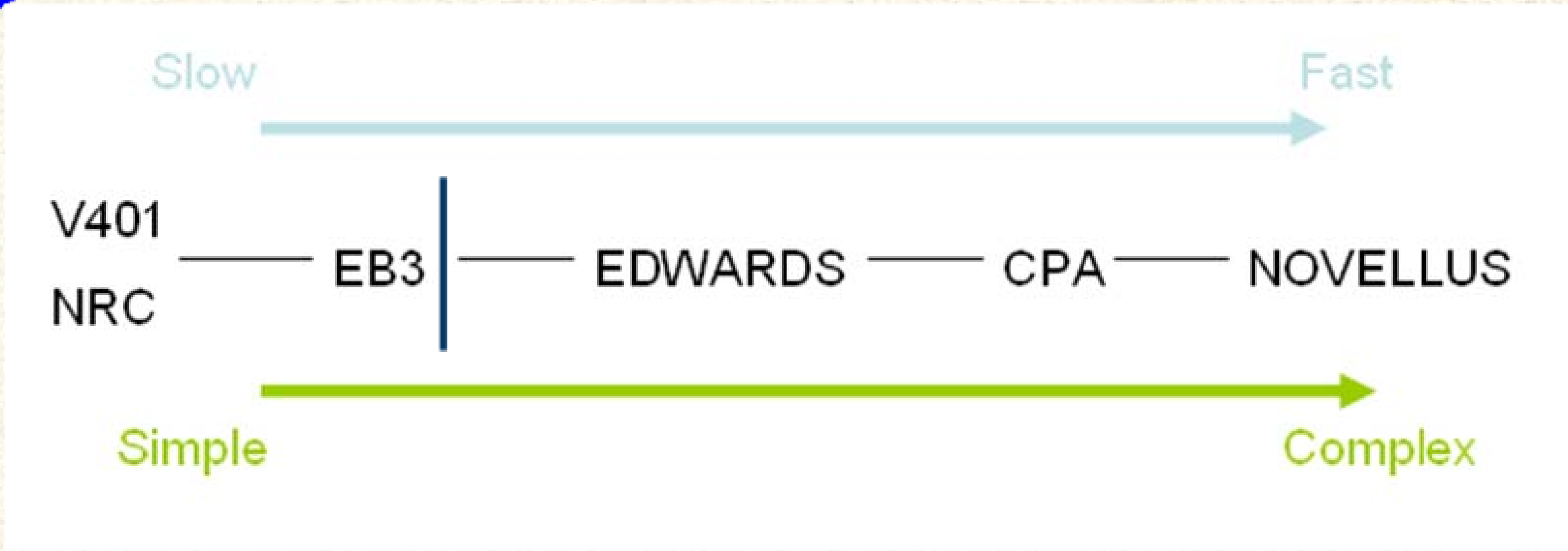
- When using NRC(1) and V401(2),
  1) a shadow formed, not allowing a even coat of aluminum
  2) the aluminum became tinted with a golden color

Solution: Re-do 2 wafers for each machine

- When developing, some of the photo-resist did not develop properly, creating an inability for the CPA wafer to etch.

Solution: Develop the wafer for a longer duration of time by developing twice

CONCLUSION



- In a lab setting, evaporating is advantageous because it is cost efficient. Although evaporating is time consuming, labs are not mass producing, therefore, mitigating the problem of time.
- Novellus outperforms in deposition rate, time, resistivity, and reflectance.
- CPA produces the most uniform layer of aluminum.

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