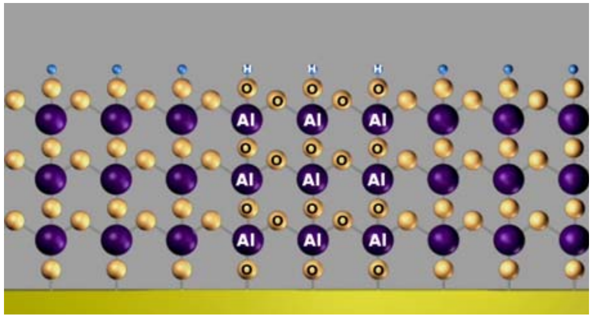
Al_2O_3 ALD



- One TMA and one H_2O vapor pulse form one cycle
- Here, three cycles are shown, with approximately 1 Å per cycle
- Each cycle including pulsing and pumping takes, e.g., 3 sec

$$\mathrm{Al(CH_3)_3\,_{(g)} + :Si\text{-}O\text{-}H\,_{(s)} \longrightarrow :Si\text{-}O\text{-}Al(CH_3)_2\,_{(s)} + CH_4}$$

$$\mathrm{2\,H_2O\,_{(g)} + :Si\text{-}O\text{-}Al(CH_3)_2\,_{(s)} \longrightarrow :Si\text{-}O\text{-}Al(OH)_2\,_{(s)} + 2\,CH_4}$$

ALD Capability

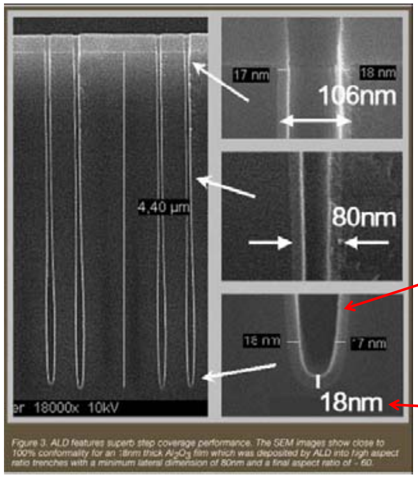


Figure 3. ALD features superb step coverage performance. The SEM images show close to 100% conformality for an 18nm thick Al_2O_3 film which was deposited by ALD into high aspect ratio trenches with a minimum lateral dimension of 80nm and a final aspect ratio of ~ 60.

Excellent conformality, even at the bottom of the trench! (aspect ratio ~60:1)

Al_2O_3

ALD Versus CVD

ALD	CVD
Highly reactive precursors	Less reactive precursors
Precursors react separately on the substrate	Precursors react at the same time on the substrate
Precursors must not decompose at process temperature	Precursors can decompose at process temperature
Uniformity ensured by the saturation mechanism	Uniformity requires uniform flux of reactant and temperature
Thickness control by counting the number of reaction cycles	Thickness control by precise process control and monitoring
Surplus precursor dosing acceptable	Precursor dosing important

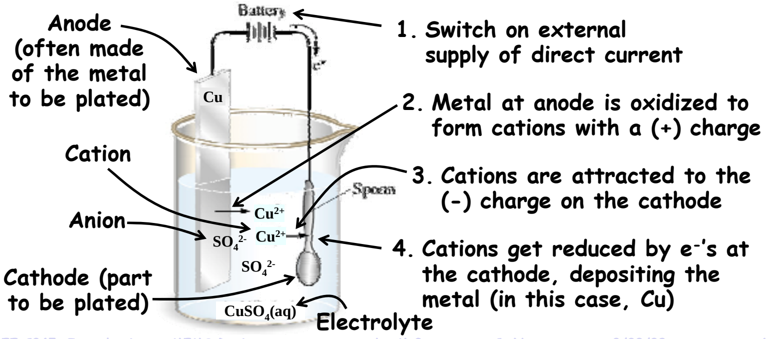
ALD Versus Other Deposition Methods

Method	ALD	MBE	CVD	Sputter	Evapor	PLD
Thickness Uniformity	Good	Fair	Good	Good	Fair	Fair
Film Density	Good	Good	Good	Good	Poor	Good
Step Coverage	Good	Poor	Varies	Poor	Poor	Poor
Inteface Quality	Good	Good	Varies	Poor	Good	Varies
Number of Materials	Fair	Good	Poor	Good	Fair	Poor
Low Temp. Deposition	Good	Good	Varies	Good	Good	Good
Deposition Rate	Fair	Poor	Good	Good	Good	Good
Industrial Apps.	Good	Fair	Good	Good	Good	Poor

Electroplating

Metal Electroplating

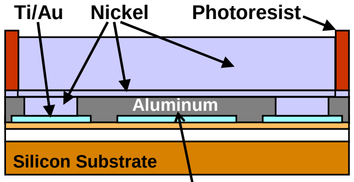
- **Electroplating**: the process using electrical current to coat an electrically conductive object with a thin layer of metal
  - ↳ Useful when very thick (>1μm) metal films are needed
  - ↳ Evaporation and sputtering generally suffer from excessive stress when films get too thick → get peeling



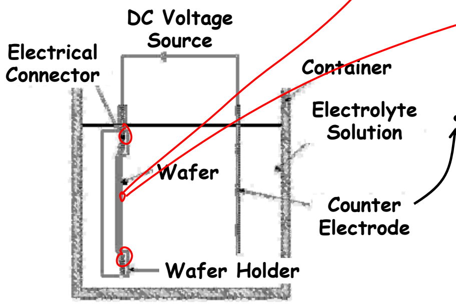
1. Switch on external supply of direct current
2. Metal at anode is oxidized to form cations with a (+) charge
3. Cations are attracted to the (-) charge on the cathode
4. Cations get reduced by e⁻'s at the cathode, depositing the metal (in this case, Cu)

Wafer-Level Implementation

- **Wafer Preparation**: areas where plating is to occur must have electrical access to the DC voltage source
  - ↳ Often use a seed layer that accesses all plating locations



Al layer insures electrical contact to plating areas, despite patterned Ti/Au



- Need not be the metal to be electroplated
  - ↳ Often just a platinum electrode
  - ↳ In this case, must replenish electrolytic solution after time