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CHE323/CHE384
Chemical Processes for Micro- and Nanofabrication
www.lithoguru.com/scientist/CHE323

Lecture 20
Evaporation, part 1

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Reading:
Chapter 12, *Fabrication Engineering at the Micro- and Nanoscale*, 4th edition, Campbell

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Deposition Techniques

- Electrochemical Deposition
  - Copper for multilevel metallization
- Chemical vapor deposition (CVD)
  - Chemical reactions on the wafer surface result in film deposition
- Physical vapor deposition (PVD)
  - Sputtering
  - Evaporation

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Evaporation

- Early technique, less common today
- Operation performed in vacuum
- The “charge” (material to be evaporated) is placed in a crucible and heated until it melts
- Evaporated material spreads in all directions
- When vapor hits cold wafer, it sticks, depositing film
- Commonly used for metal deposition

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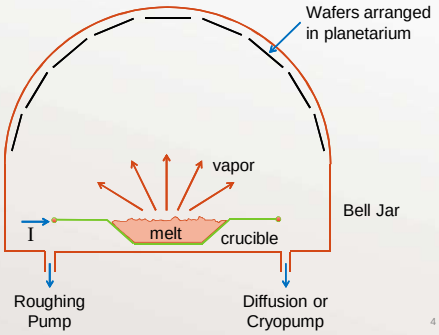
Evaporation



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Options for Melting the Charge

- Run current through the crucible (e.g., tungsten)
  - Problem: if melting point of charge is high (e.g, refractory metals), crucible will sublimate, contaminating the deposition and the charge
- Inductively heat the charge (RF energy)
  - Reduces but does not eliminate crucible heating
- E-beam evaporation

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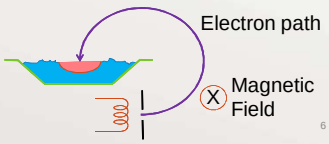
E-beam Evaporation

- Electrons bombard the charge, causing it to locally heat up. Crucible is cooled – melt is surrounded by solid charge
  - Problem: X-rays and secondary electrons are generated, which can damage the wafer, cause trapped charge in gate oxide, etc.



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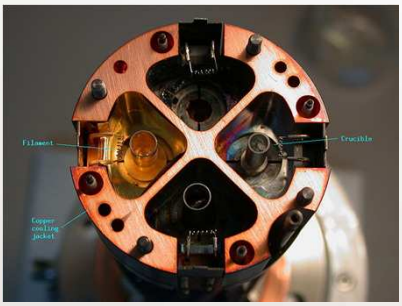
E-Beam Evaporation Source



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Depositing Alloys

- Use alloy charge
  - Problem: different alloy components melt at different temperatures
- Use multiple crucibles, independently heated
  - Problem: hard to control deposition rates well enough to get consistent composition

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Deposition Control

- Deposition rates are a strong function of melt temperature (difficult to control)
- Solution: process control
  - Measure deposited thickness in real time
  - When thickness reaches target, close shutter
- Thickness measurement:
  - Quartz crystal microbalance
  - Frequency of oscillation is proportional to mass of deposited material (and thus thickness)

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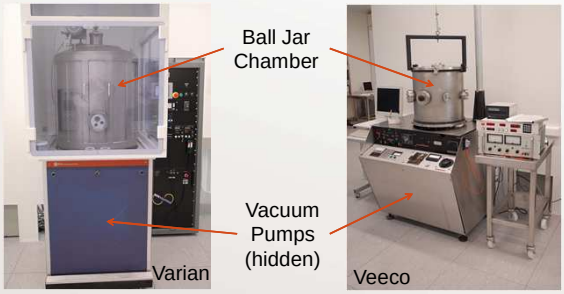
Evaporation Equipment



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Lecture 20: What have we learned?

- What are the three common deposition methods used in semiconductor manufacturing?
- What are the different methods for melting the charge, and their advantages and disadvantages?
- Explain how e-beam evaporation works
- How is film thickness controlled in evaporation systems?

