Lecture 23
Sputtering, part 2

Chris A. Mack
Adjunct Associate Professor

Step Coverage

- Step coverage is good (but not perfect) due to range of incoming angles
- Shadowing still occurs
- Heating wafer increases mobility after sticking
  - Metal grains can form if too hot, increasing roughness
  - Specular reflectivity used to monitor roughness (lower spec limit)

Via Fill Application

- To eliminate voids, we want poor step coverage
  - Use CMP to polish down to a "plug"

To Reduce Step Coverage

- Reduce pressure to a few millitorr
  - Mean free path increases to ~1 cm
- Use collimators to direct the sputtered atoms vertically

Sputter Cleaning

- If the wafer has a negative bias compared to the plasma, Ar+ will sputter etch the wafer
  - This can be used to clean the wafer before deposition begins
    - Can also remove native oxide on silicon
  - Problem: can cause damage to substrate
Bias Sputtering
• Sputter etching during deposition can improve step coverage

Example Process
• Aluminum alloy deposition
  – Al + 2% Si + 0.5% Cu
• Planar DC magnetron
  – High deposition rate
  – O₂ and N₂ in chamber must be kept very low

Stress
• Stress in metal films affects reliability
  – Strain-induced diffusion of grain boundaries
• Thermal mismatch of metal vs. substrate is one cause of stress when deposition is not done at room temperature
• Stress is measured as a change in wafer bow before and after deposition

Film Quality
• Composition and impurities, stoichiometry
• Electrical and mechanical properties
  – Breakdown voltage, resistivity, stress
• Defects (pinholes, particles)
• Adhesion
• Thickness (accuracy and uniformity)
• Step coverage (planarizing vs. conformal)
• Reflectivity (roughness) and refractive index

Lecture 23: What have we learned?
• How is step coverage controlled in sputter deposition systems?
• What step coverage is needed for the via fill application?
• What causes stress in deposited films, and how is it measured?
• How many aspects of film quality can you name?