Thin Film Growth and Analysis

April Hersey

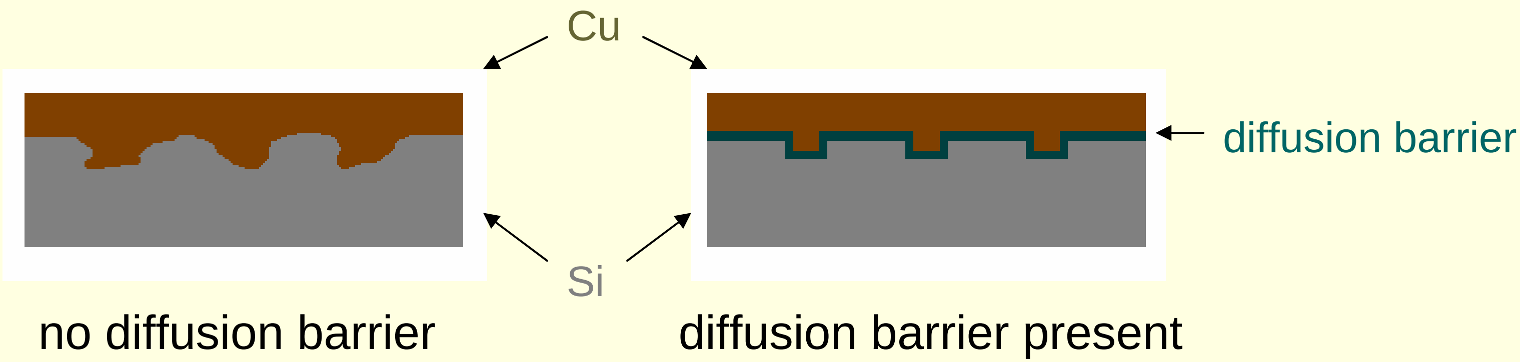
August 15, 2007

Outline

- Background
- Purpose of experiments
- What I did in the lab
- Surface Science Chamber
  - X-ray Photoelectron Spectroscopy
  - Temperature Programmed Desorption
- Chemical Vapor Deposition
- Reflections on the lab

Background

- Computer speed increases with number of transistors per chip
- Transistor size must decrease to fit more transistors on each chip
- Metal interconnects on chips tend to diffuse into transistors; these layers must be separated with diffusion barrier
- Diffusion barrier must be made from more stable material



Purpose

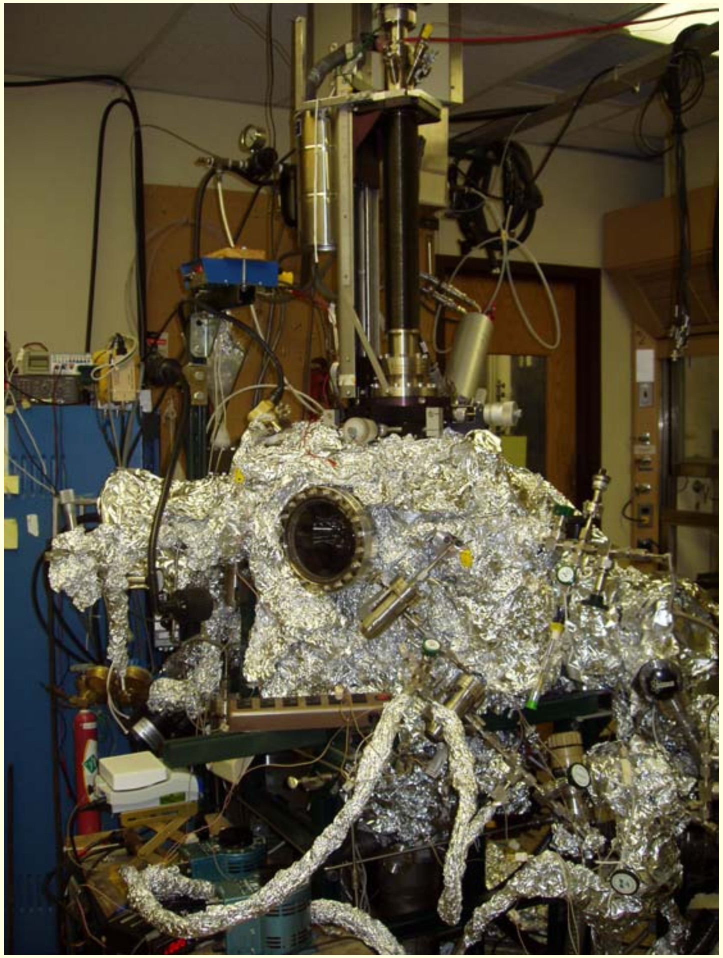
- To find a better diffusion barrier material
- Should have the following properties:
  - prevents diffusion between device layers
  - non-reactive with neighboring device components
  - can be deposited at a low temperature
  - is sufficiently uniform

What I Did in the Lab

- Learned purpose for experiments
- Took data from the surface science chamber using the XPS and TPD processes
- Grew films inside the CVD chamber
- Cut silicon dioxide squares for the CVD chamber

Surface Science Chamber

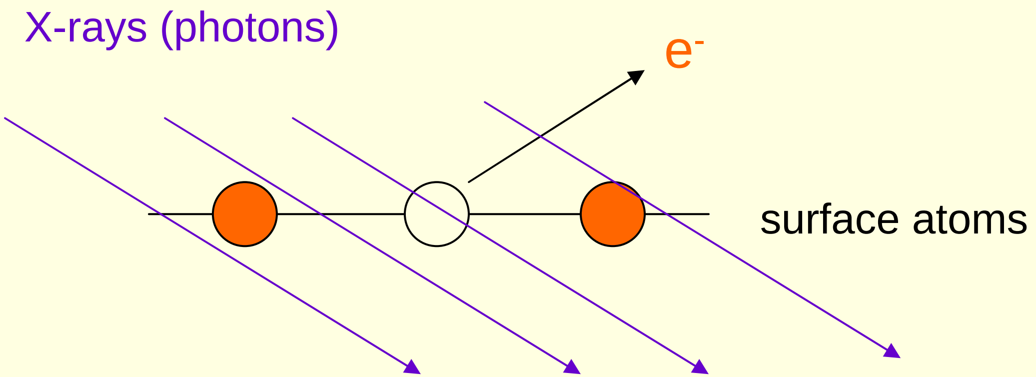
- Ultra-high vacuum (UHV) chamber
- Cryogenic and diffusion pumps
- Sample manipulator
- Liquid nitrogen sample cooling
- Resistive heating
- Computer and software



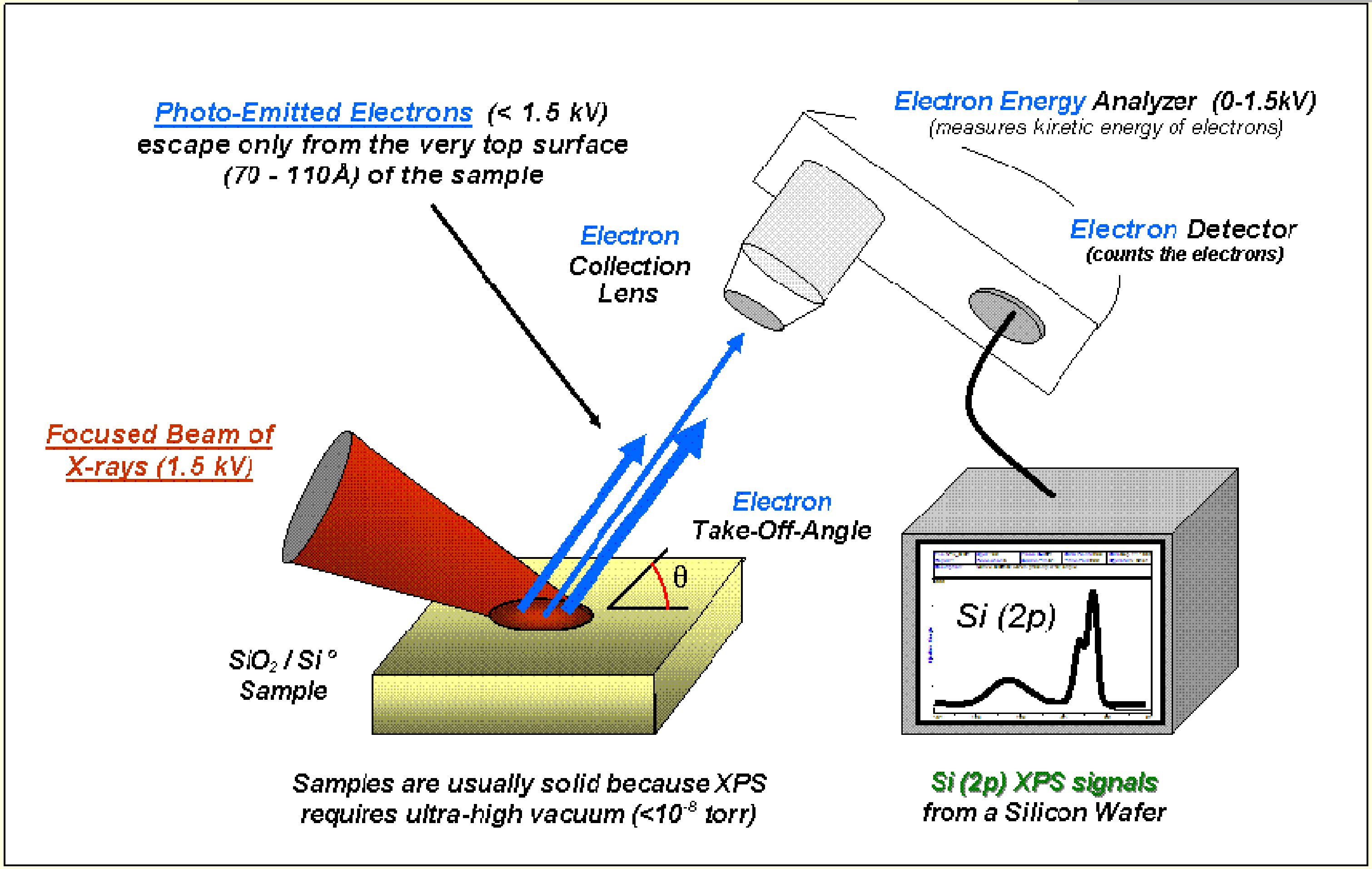
X-ray Photoelectron Spectroscopy (XPS)

- X-ray photons sent toward substrate to knock electrons out of their shells (photoelectric effect)
- Electrons are emitted at certain energy levels, depending on what element they came from
- Binding energy is measured to determine what elements are present on surface of substrate

electron emission due to the photoelectric effect

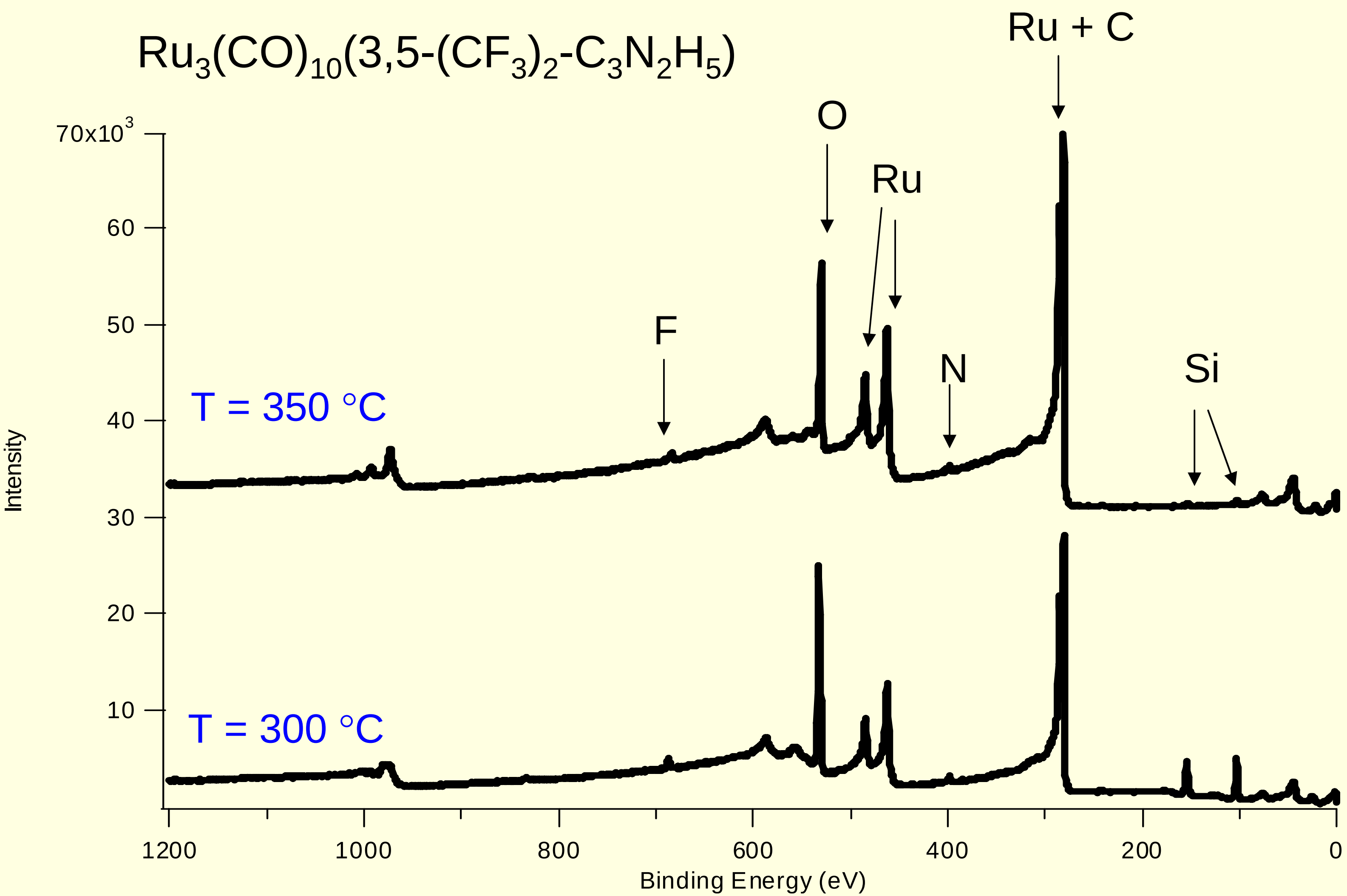


X-ray Photoelectron Spectroscopy (XPS)



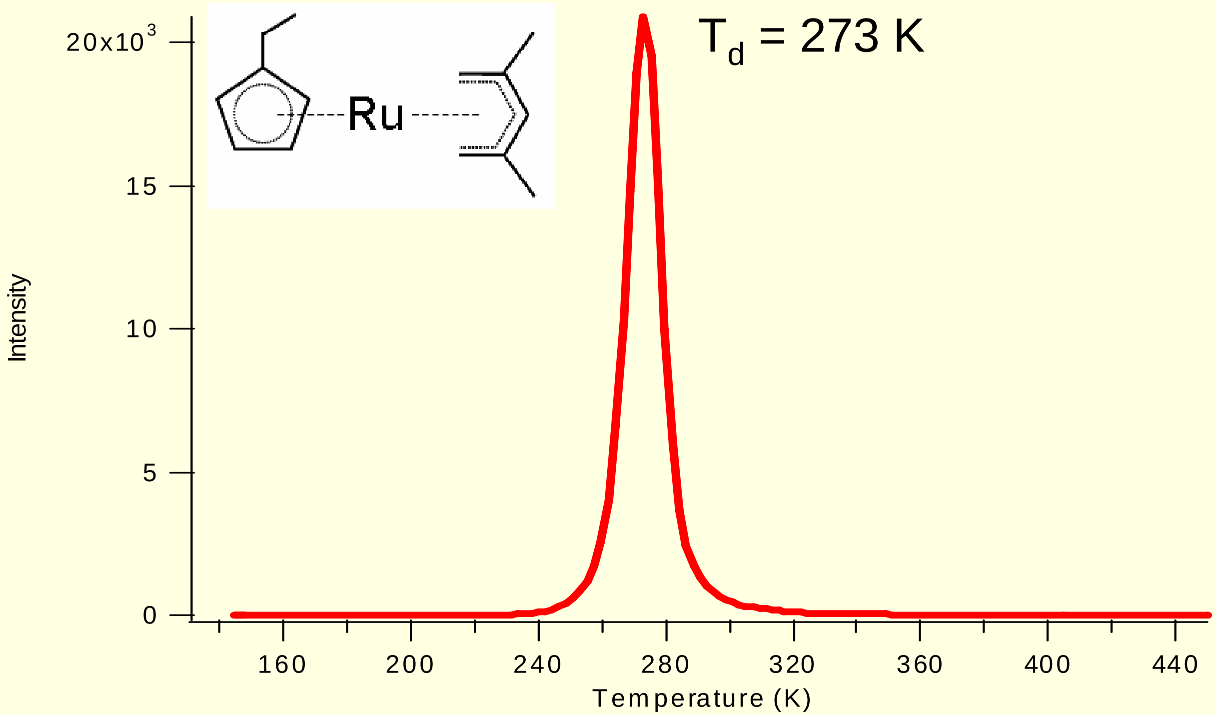
http://en.wikipedia.org/wiki/Image:System2.gif

X-ray Photoelectron Spectroscopy (XPS)



Temperature Programmed Desorption (TPD)

- Substrate is heated at 7 K/s
- Determines:
  - What temperature molecules desorb from the surface
  - Whether the molecules remain intact or break into fragments



Surface Science Chamber

- XPS to make sure surface is clean before experiment
- Sample is moved into dosing position and held at 140 K
- Precursor is released into the chamber for a set period of time
- XPS to determine:
  - the different elements present in the precursor
  - the ratio of those elements in relation to each other
  - how those elements are bonded to one another
- TPD
- XPS to determine how much precursor remains on the surface after TPD

Surface Science Chamber

- Data shows what molecules from the precursor adsorb onto the surface and at what temperature they desorb from the surface
- Results may determine whether the precursor could be used to grow a film in the CVD chamber

Chemical Vapor Deposition (CVD)

- Horizontal tube furnace
- Gas lines
- Mass flow controller
- Mechanical pump
- Saturator
- Heating tape

Chemical Vapor Deposition (CVD)

- Substrate, a square of silicon dioxide, is placed in a sample boat and slid into the tube furnace
- Furnace is set to a certain temperature
- Pressure is maintained at 0.300 Torr
- Saturator containing the precursor is heated to a certain temperature; gas lines are heated 10 °C higher than the saturator
- Precursor is transported to the furnace by argon gas and adsorbs onto the surface of the substrate
- After set growth period, sample is allowed to cool inside the chamber

Chemical Vapor Deposition (CVD)

- Analysis can suggest:
  - Whether a film of precursor can be grown at the set temperature
  - Whether precursor and/or reaction products adsorbed onto the substrate
  - Uniformity of the film
  - Whether the precursor could be used as an effective diffusion barrier

Reflections on the lab

- Less strict lab safety
- Equipment oddities
- Wait time during experiments
- Intriguing subject matter

Thank You

- Alex Demkov
- Dr. John Ekerdt/Ekerdt Group
- Kelly Thom, mentor