Lecture 1 - Introduction to Semiconductors - Outline

- **Introductions/Announcements**
  - Staff
  - Materials - 1. General information, readings (4 pages)
    2. Syllabus
    3. Student info sheet (for tutorials, due now!)
    4. Course notes receipt (pick up full set [Parts I and II)
    5. Diagnostic exam (try it; solutions out soon)
    6. Lecture 1 Outline and Summary
  - Rules and regulations (next foil)
- **Why semiconductors, devices, circuits?**
- **Mobile charge carriers in semiconductors**
  - Crystal structures, bonding
  - Mobile holes and electrons
  - Dopants and doping
- **Silicon in thermal equilibrium**
  - $n_o p_o$ product
  - n_o, p_o given N_d, N_a
  - n-type, p-type

Comments/Rules and expectations

Recitations: re-enforce lecture
some new material
very important

Tutorials: begin Monday, September 8
assignments will be posted on web

Homework: very important to learning material; do it!!

Cheating: what you turn in must be your own work. It is OK to discuss it with others, but when you prepare your solution you should work on it alone.

Reading assignment (Lec. 1)

Chapter 1 in text
Chapter 2 in text

SEMICONDUCTORS: They are here, there, and everywhere

- **Computers, palm pilots, laptops, anything "intelligent"** — Silicon (Si) MOSFETs, ICs, CMOS
- **Cell phones, pagers** — Si ICs, GaAs FETs, BJTs
- **CD players** — AlGaAs and InGaP laser diodes, Si photodiodes
- **TV remotes, mobile terminals** — Light emitting diodes
- **Satellite dishes** — InGaAs MMICs
- **Fiber networks** — InGaAsP laser diodes, pin photodiodes
- **Traffic signals, car taillights** — GaN LEDs (green, blue), InGaAsP LEDs (red, amber)
- **Air bags** — Si MEMs, Si Ics

and, they are important, especially to EECS types!!

Why semiconductor materials and devices?

They are everywhere!

They provide:

a good intellectual framework and foundation,
and
a good vehicle and context

with which

to learn about modeling physical processes,
and
to begin to understand electronic circuit analysis and design.

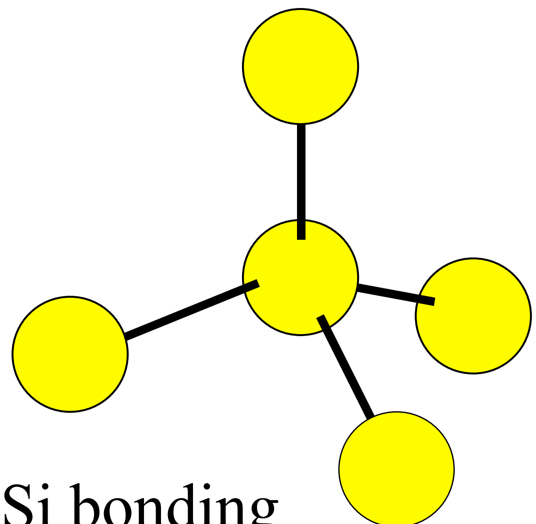
Silicon: our primary example and focus

Atomic no. 14

14 electrons in three shells: 2) 8) 4

i.e., 4 electrons in the outer "bonding" shell

Silicon forms strong covalent bonds with 4 neighbors



Si bonding configuration

See pg.13 of Sze, S.M. *Physics of Semiconductor Devices*. ISBN 471-842-90-7.

Silicon crystal ("diamond" lattice)

Lecture 1 - Introduction to Semiconductors - Summary

- **Introductions/Announcements**
  This is going to be a great course
- **Why semiconductors, devices, circuits?**
  Fascinating, instructive, and important as well
- **Mobile charge carriers in semiconductors**
  Covalent bonding, 4 nearest neighbors, diamond lattice
  Conduction electrons: charge = – q, concentration = n [cm^{-3}]
  Mobile holes: charge = + q, concentration = p [cm^{-3}]
  Electron-hole pair generation/recombination occurs continuously
  Donors: Column V (P,As,Sb); fully ionized at RT: $N_d^+ \approx N_d$
  Acceptors Column III (B); fully ionized at RT: $N_a^- \approx N_a$
- **Silicon in thermal equilibrium**
  Intrinsic (pure) Si: $n_o = p_o = n_i(T) = 10^{10}$ cm^{-3} at RT
  Doped Si: always $n_o p_o = n_i^2$; no net charge (mobile + fixed = 0)
  If $N_d > N_a$, then: $n_o \approx N_d - N_a$; $p_o = n_i^2/n_o$; called "n-type";
  electrons are the majority carriers, holes the minority
  If $N_a > N_d$, then: $p_o \approx N_a - N_d$; $n_o = n_i^2/p_o$; called "p-type";
  holes are the majority carriers, electrons the minority