Lecture 1

Instructor and TA Info

Instructor:	Prof. Daniel J. Blumenthal
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Lecture:	Tues/Thurs 11:00pm – 12:15pm; Phelps 1444
Makeup Class:	Fri. 10:00pm – 12:15pm; TBD
Discussion:	Thurs: 3:00 – 6:50pm; Phelps 1445
Office Hours:	TBD
Course Website:	TBD
TA:	Wenzao Li (Email: wli@ece.ucsb.edu; Phone: (805) 220-8748)
TA Office Hours:	TBD

Homework and Grading

Homework:

Will be assigned each week on Tuesday and due the following Thursday at the start of class. Late homework up to 1 day late will receive 20% reduction in grade. Assignments handed in more than 1 day after due date will not be graded.

Grading:

Homework:	30%
Midterm Exam:	30%
Final Exam:	40%

Course Topics

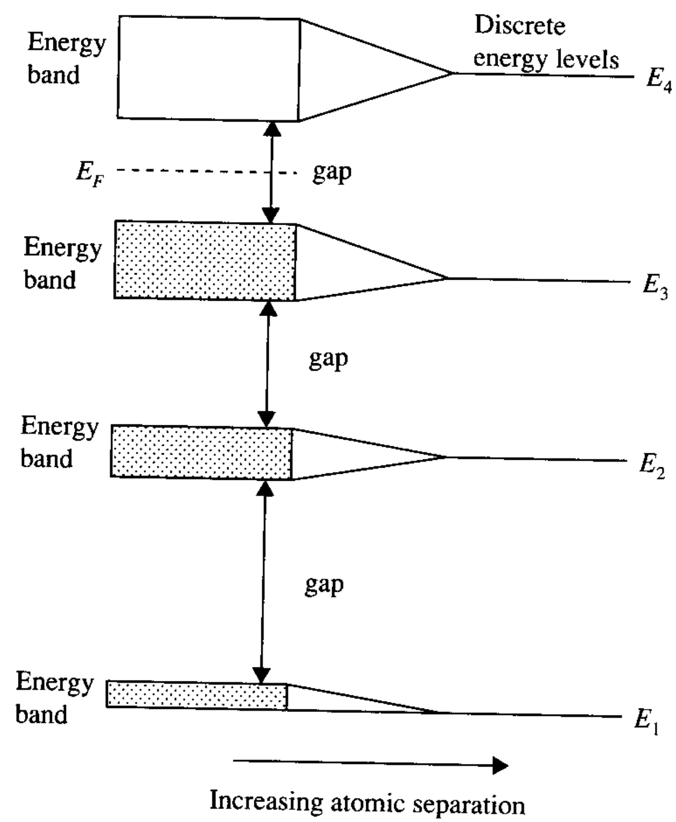
1. Bonds
   a) Intro
   b) General mechanical properties of bonds
   c) Bond Types
   d) Feynman’s coupled mode approach
   e) Nuclear Forces
   f) The Hydrogen molecule
2. The Free Electron Theory of Metals
   1. Free electrons
   2. The density of states and the Fermi-Dirac function
   3. The specific heat of electrons
   4. The work function
   5. Themionic emission
   6. The Schottky effect
   7. Field Emission
   8. The field-emission microscope
   9. The photoelectric effect
   10. Quartz-Halogen lamps
   11. The junction between two metals

Course Topics

3. The Band Theory of Solids
   a) The Kronig =-Penny model
   b) The Ziman model
   c) The Feynman model
   d) The effective mass
   e) The effective number of free electrons
   f) The number of possible states per band
   g) Metals and insulators
   h) Holes
   i) Divalent metals
   j) Finite temperature
4. Semiconductors
   a) Intrinsic Semiconductors
   b) Extrinsic semiconductors
   c) Scattering
   d) Relationship between electron and hole densities
   e) III-V and II-VI compounds
   f) Non-equilibrium processes
   g) Real semiconductors
   h) Amporphous semiconductors
   i) Measurement of semiconductor properties
   j) Preparation of pure and controlled-impurity single-crystal semiconductors

Origin of SC Bandgap

- The discrete energy states of electrons in an atom are broadened from the individual atom states into energy bands as the atoms are brought closer together to form a crystal.
- When the bandgap energy is on the order of 2eV, room temperature thermal energy can break covalent bonds and accelerate ionized electrons into empty states in the crystal where they can conduct electrically -> Semiconductors

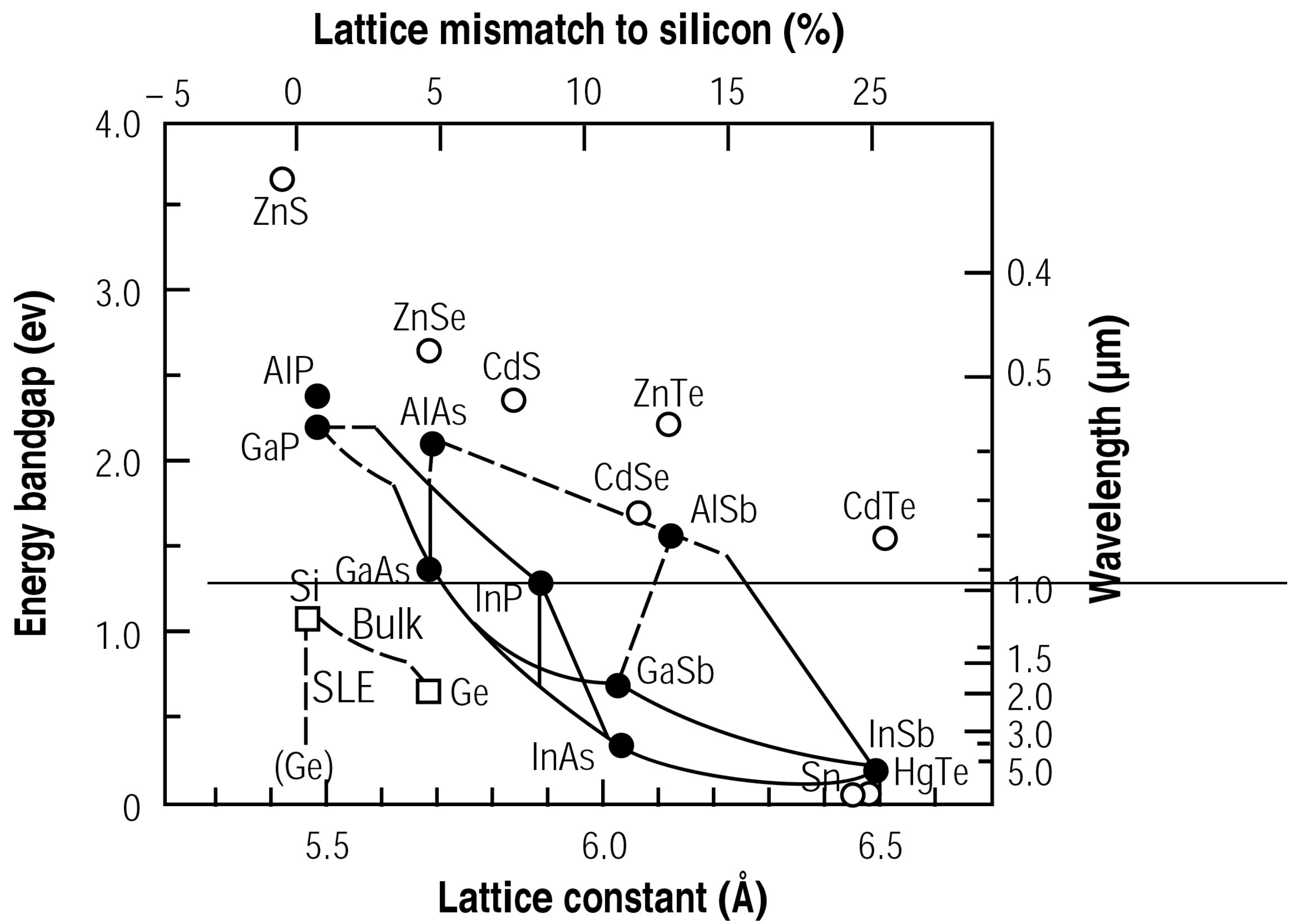


Ternary Materials

- Mix two binaries together. The bandgap is approximately the arithmetic average of the two (Vegard's law) e.g. $Ga_xAl_{1-x}As$
- There are two types of sites: group III and group V. (II-VI compounds also possible).
- Ternaries cannot be grown on binary substrates in general because the lattice constants don't line up and dislocations occur. Special case: $Ga_xAl_{1-x}As$ because the lattice constants of GaAs and AlAs are almost equal.

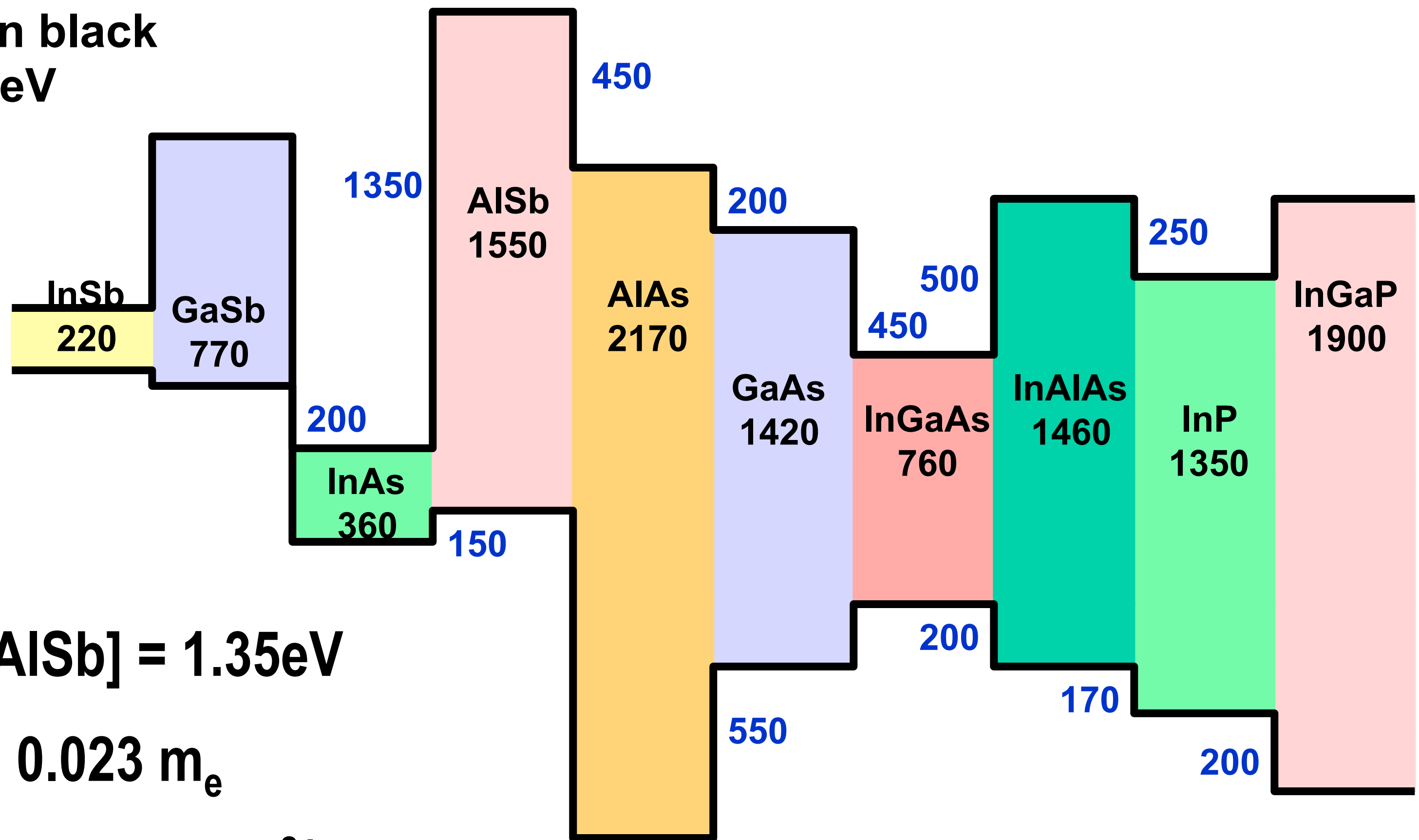
Quaternary materials

- To match bandgap and lattice constant, two degrees of freedom are required.
- Example: $Ga_xIn_{1-x}As_yP_{1-y}$
  - X is the fraction of group III sites occupied by Ga.
  - Y is the fraction of group V sites occupied by As.
- In a bandgap chart, the dots are binaries, the lines are ternaries, and the regions bounded by 4 lines are quaternaries.


Lattice mismatch to silicon (%)
– 5
0
5
10
15
25
4.0
3.0
2.0
1.0
0
Energy bandgap (ev)
ZnS
ZnSe
CdS
ZnTe
AlP
GaP
AlAs
CdSe
AlSb
CdTe
GaAs
Si
InP
Bulk
SLE
Ge
GaSb
(Ge)
InAs
InSb
Sn
HgTe
0.4
0.5
1.0
1.5
2.0
3.0
5.0
Wavelength (μm)
5.5
6.0
6.5
Lattice constant (Å)

Bandgap Heaven

- Offsets in blue #s
- Bandgaps in black
- Units are meV



ΔE_C [InAs-AlSb] = 1.35eV

m* [InAs] = 0.023 m_e

InAs RT μ > 30,000 cm^2/Vs