Design flow of IC

- Concept realized by RTL. Hardware language coding.
- Synthesize by the logic gates.
- Translate into layout.
- Digital Logic gates consists of transistor. Pull and Push mechanism.

Components

- Passive components such as resistors and capacitor.
- Active component is transistor.
- Circuit is printed on the wafer.

Semiconductor Materials

1. Semiconductor are a group of materials having electrical conductivities intermediate between metal and insulator.
2. The conductivity of these material can be varied by changes in temperature, optical excitation and impurity content.
3. This variability of electrical properties makes the semiconductor materials natural choices for electronic device investigation.

Semiconductor Material

- Semiconductor materials are found in column IV and neighboring column of periodic table.
- The column IV semiconductor are called elemental semiconductor because the are composed of single species of atom.
- In addition to elemental material , compounds of column III and V also can make up compound semiconductor.
- The elemental semiconductor Ge was widely used in the early days of semiconductor development for transistors and diodes.
- Silicon is now used majority in transistors , rectifiers and integrated circuits.

Semiconductor Material

- One of the most important characteristic of a semiconductor which distinguishes it from metals and insulator is its energy bandgap.
- This property determines the wavelength of the light that can be absorbed or emitted by semiconductor.
- Example : Band gap GaAs = 1.43 electron volt (eV)
- The electronic and optical properties of semiconductor are strongly affected by impurity.
- The impurities can be used to vary the conductivities of semiconductor over wide ranges and even alter the nature of the conduction. Ie –ve charge carrier to +ve charge carrier.

Semiconductor Material

- To investigate the useful properties of semiconductor it is necessary to understand the atomic arrangements in the materials.

Crystal lattice

- Periodic structure.
- The crystalline solid is distinguished by the facts that the atoms making up the crystals are arranged in periodic fashion.
- The basic atoms arrangement of atoms repeated throughout the entire solid.
- The periodic arrangement of atoms in crystal is lattice.

Crystal lattice

- Since there are many different ways of placing atoms in the volume, distance and orientation can make many forms.
- In every case the volume is called unit cell. The representative of entire crystal and regularly repeated throughout crystal.
- The smallest unit cell that can be repeated to form the lattice is called primitive cell.

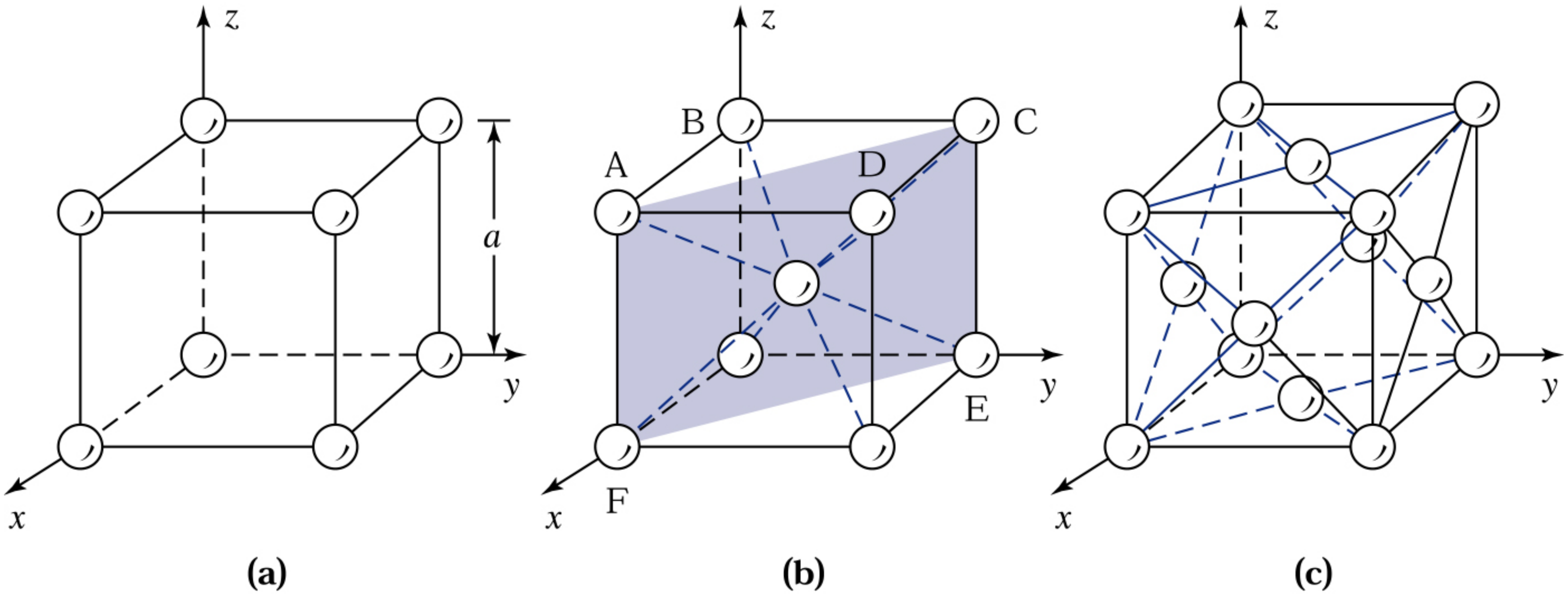
Crystal lattice

- Important for our interest in electronic device, the properties of the periodic crystal determine the allowed energy of electrons that participate in the conduction process.
- Thus the lattice not only determine the mechanical properties of the crystal but also the electrical properties.

Cubic lattice

- The simplest three dimensional lattice is one in which the unit cell is a cubic volume.
- Among : simple cubic (sc), body centered cubic (bcc) and face centre cubic (fcc)
- Simple cubic has an atom located at each corner.
- Body centered has an additional atom located at the centre of the cube.
- Face centered (fcc) unit cell has atoms at the eight corners and centered on the six faces.

Three cubic-crystal unit cells. (*a*) Simple cubic. (*b*) Body-centered cubic. (*c*) Face-centered cubic.



Cubic Lattice

- The dimension a for a cubic unit cell is called lattice constant.
- For the fcc lattice the nearest neighbor distance is one half the diagonal face

Planes and Direction

- In discussing crystal it is very helpful to be able to refer to planes and direction within lattice.
- Three integers describing the particular plane are found in the following ways.
- Find the intercepts of the plane.
- Take the reciprocals.
- Label the plane (hkl)

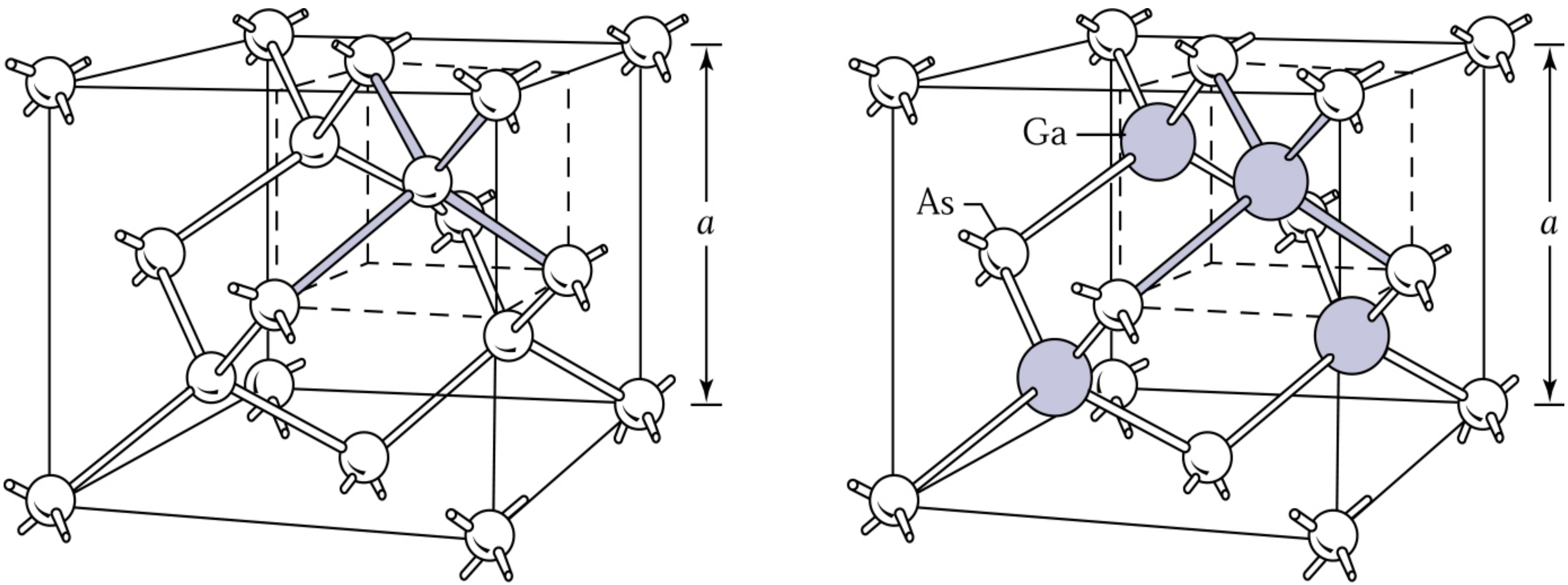
Plane and Directions

- The hkl is called Miller indices.
- From crystallographic point of view many planes in the lattice are equivalent.

The diamond lattice

- The basic lattice structure for many important semiconductor is diamond lattice.
- This is the characteristic of Si and Ge.

Figure 2.4. (*a*) Diamond lattice. (*b*) Zincblende lattice.



(a)   (b)

Bulk Crystal Growth

- The progress of the solid state depend not only on the device concept but also the improvement of the material.
- The integrated that being made today is the result of considerable breakthrough of of pure and single crystal in the 50's.
- Start from silicon dioxide react with C in high temperature.
- Final crystal is produced using Czochralski method.

Wafer

- After single ingot is grown it is then mechanically processed to manufacture wafer.
- Most silicon ingot is grown along <100> direction.

Energy Band

- In order to study the properties of semiconductor devices (diodes, transistor, integrated circuit it is essential to posses some knowledge in materials.
- The main material for semiconductor today is silicon.
- The resistivity of semiconductor is controlled by impurities.
- Silicon is most used semiconductor because of technology.

Energy Band

- According to Niels Bohr postulated that the orbit of the electron around the nucleus could only lie in one fix number of orbital.
- Each orbital correspond to energy level , E1 , E2 and E3.
- The meaning of energy of an electron in particular orbital can be best tought as the energy that must be given to electron in order to separate it from the atom.

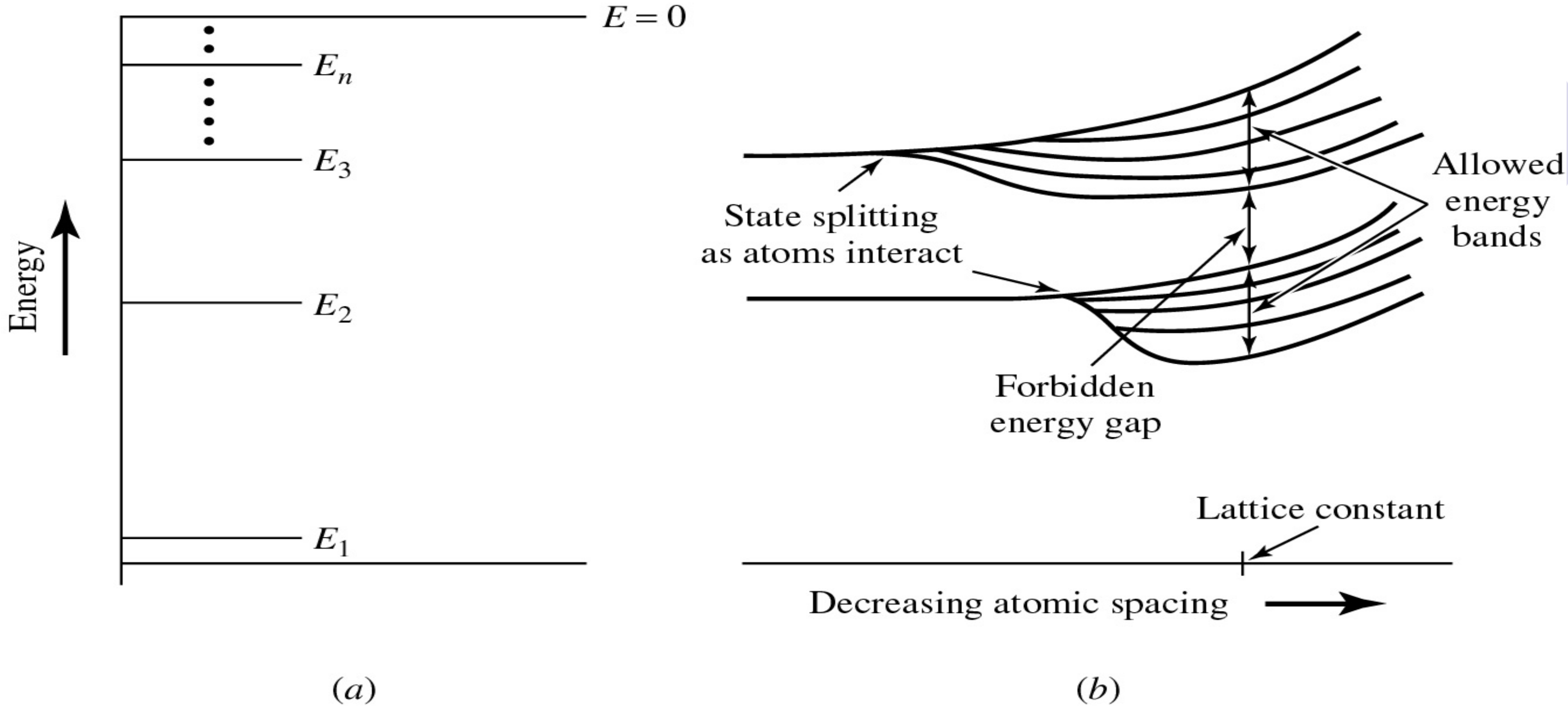


Figure 1.1 (p. 3)
(*a*) Allowed energy levels of an electron acted on by the Coulomb potential of an atomic nucleus. (*b*) Splitting of energy states into allowed bands separated by a forbidden energy gap as the atomic spacing decreases; the electrical properties of a crystalline material correspond to specific allowed and forbidden energies associated with an atomic separation related to the lattice constant of the crystal.

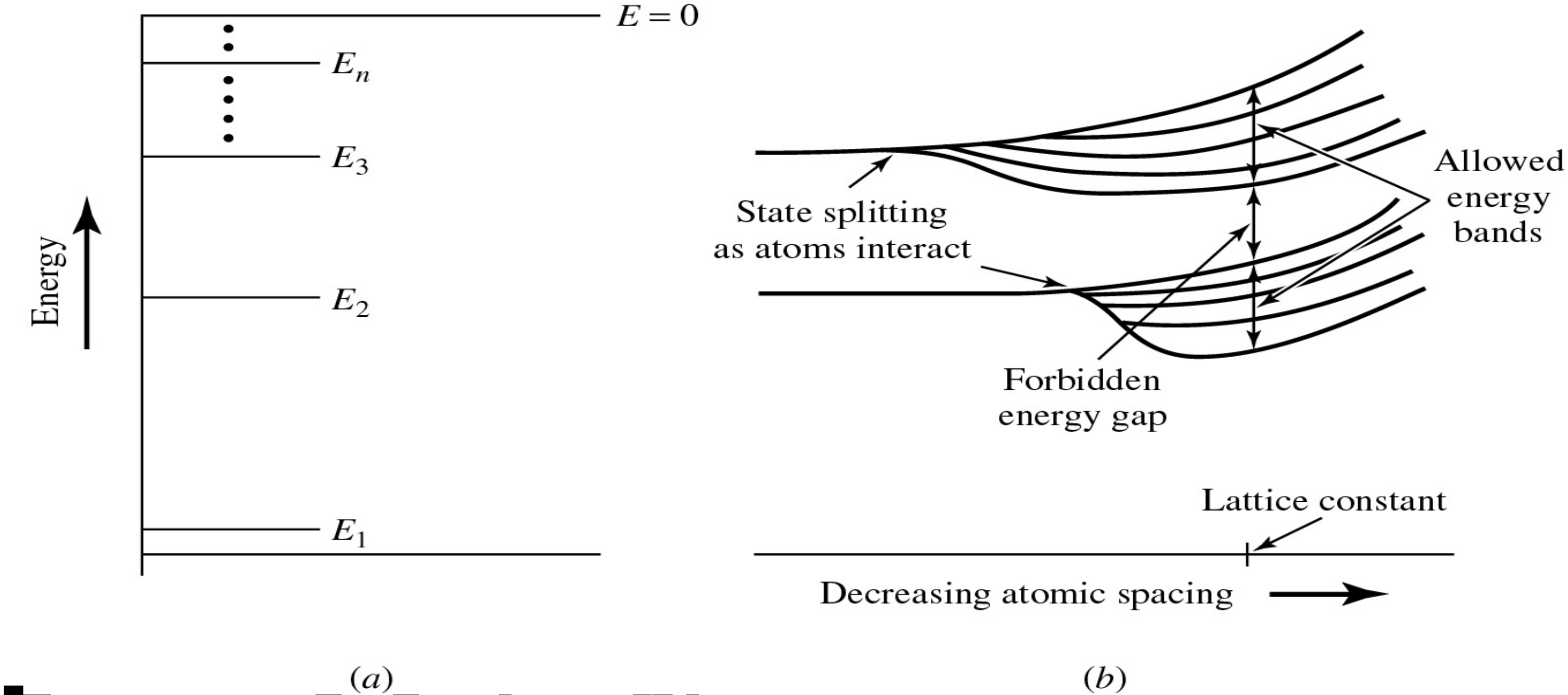


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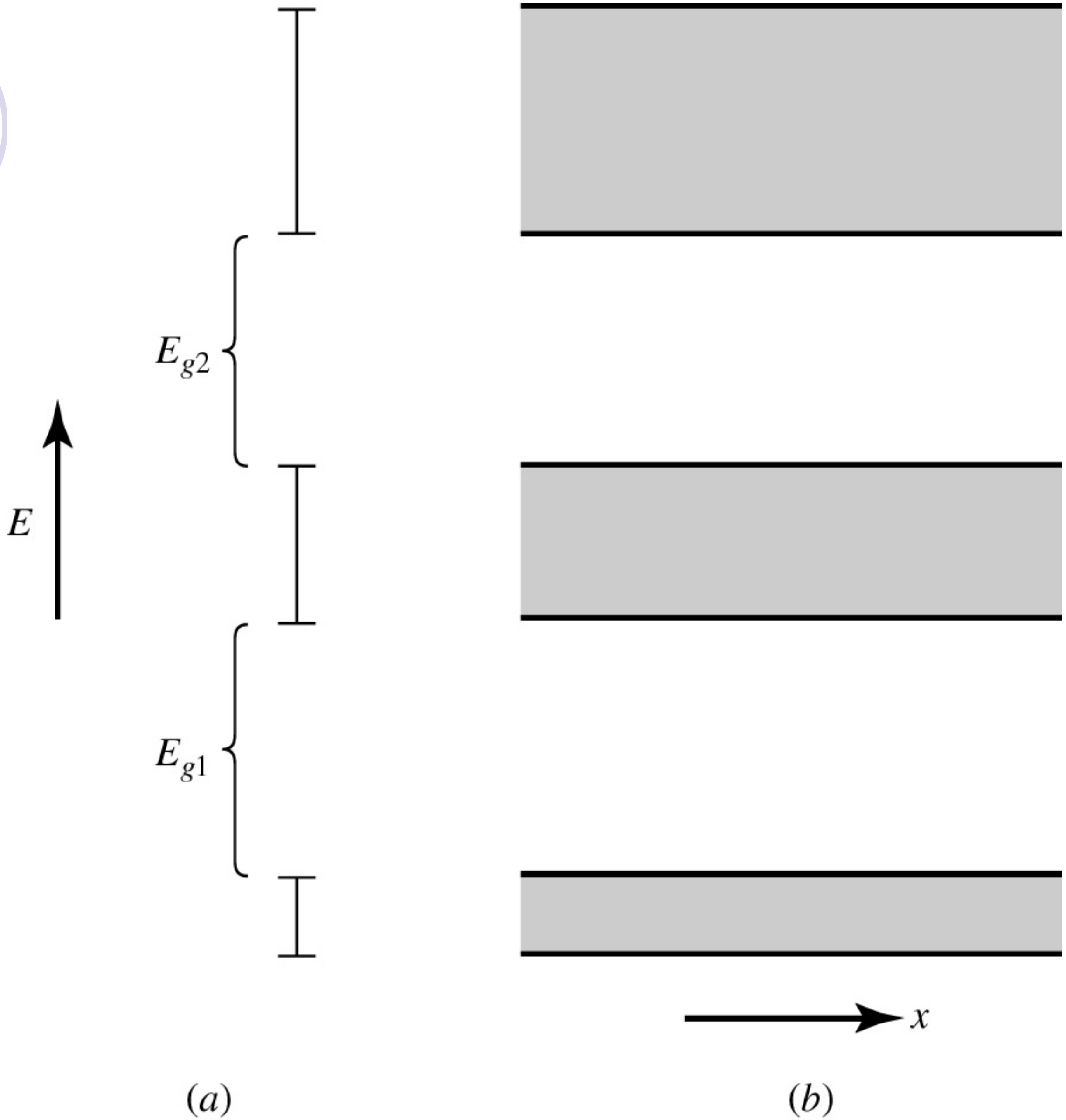
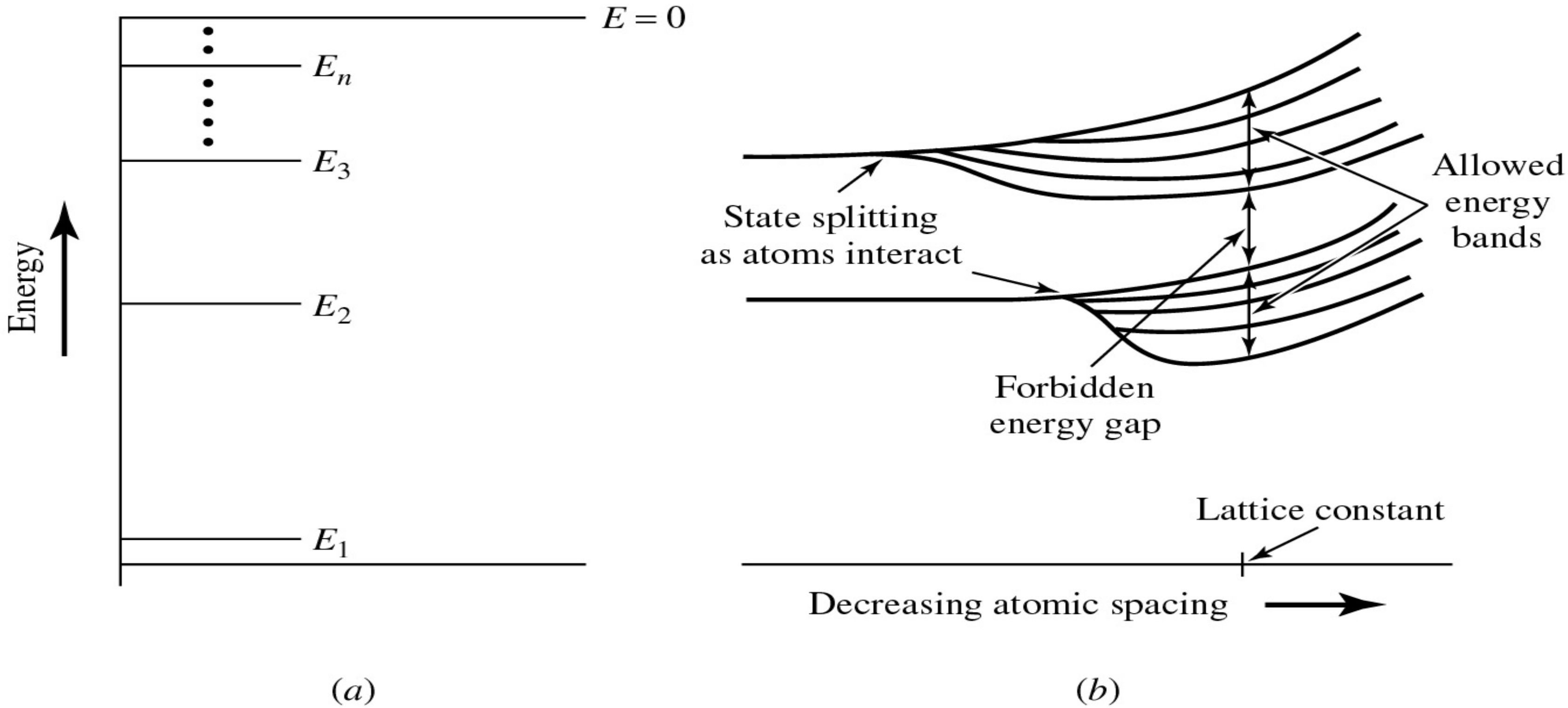
Figure 1.2 (p. 4)
Broadening of allowed energy levels into allowed energy bands separated by forbidden-energy gaps as more atoms influence each electron in a solid; (*a*) one-dimensional representation; (*b*) two-dimensional diagram in which energy is plotted versus distance.





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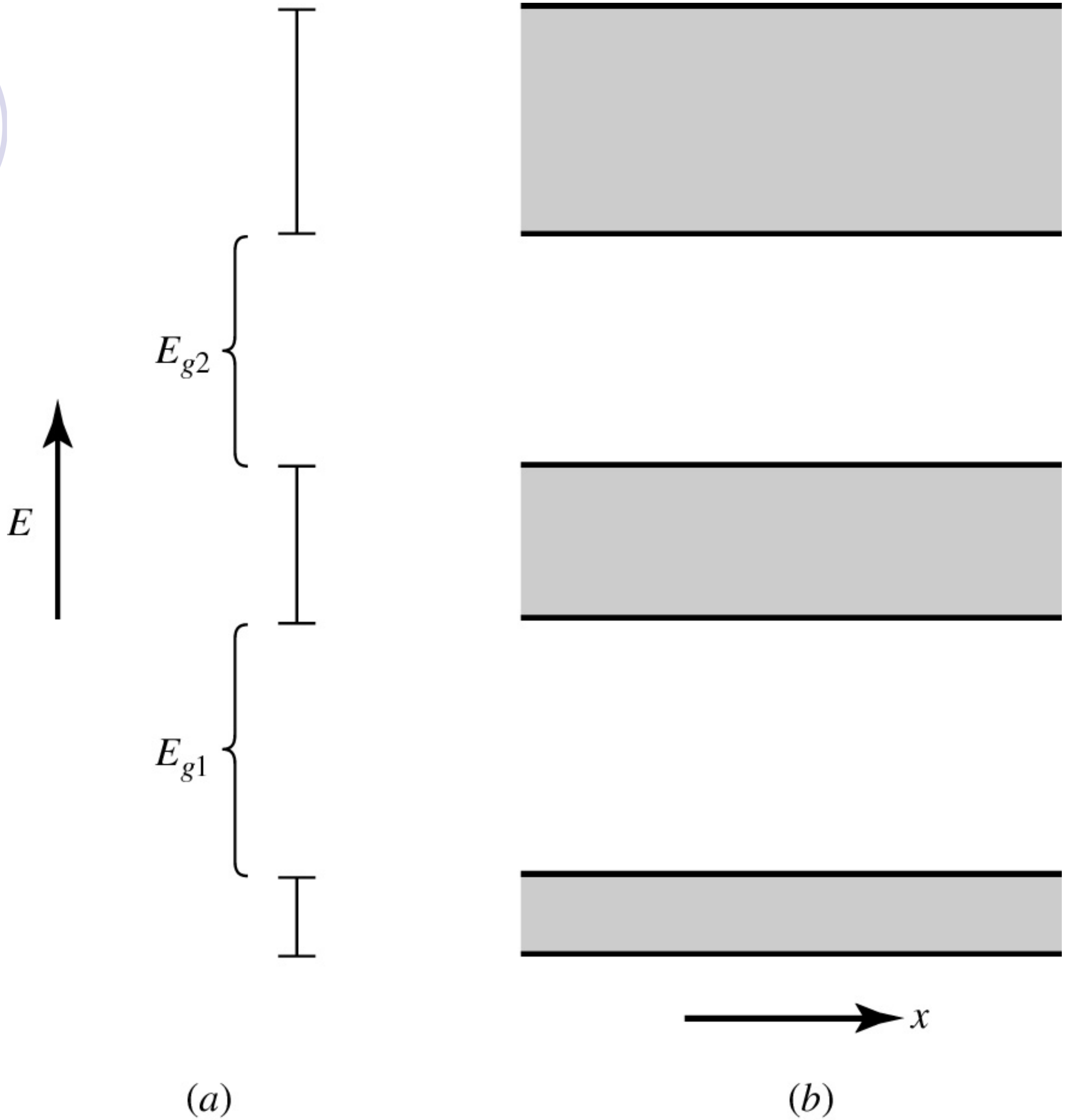

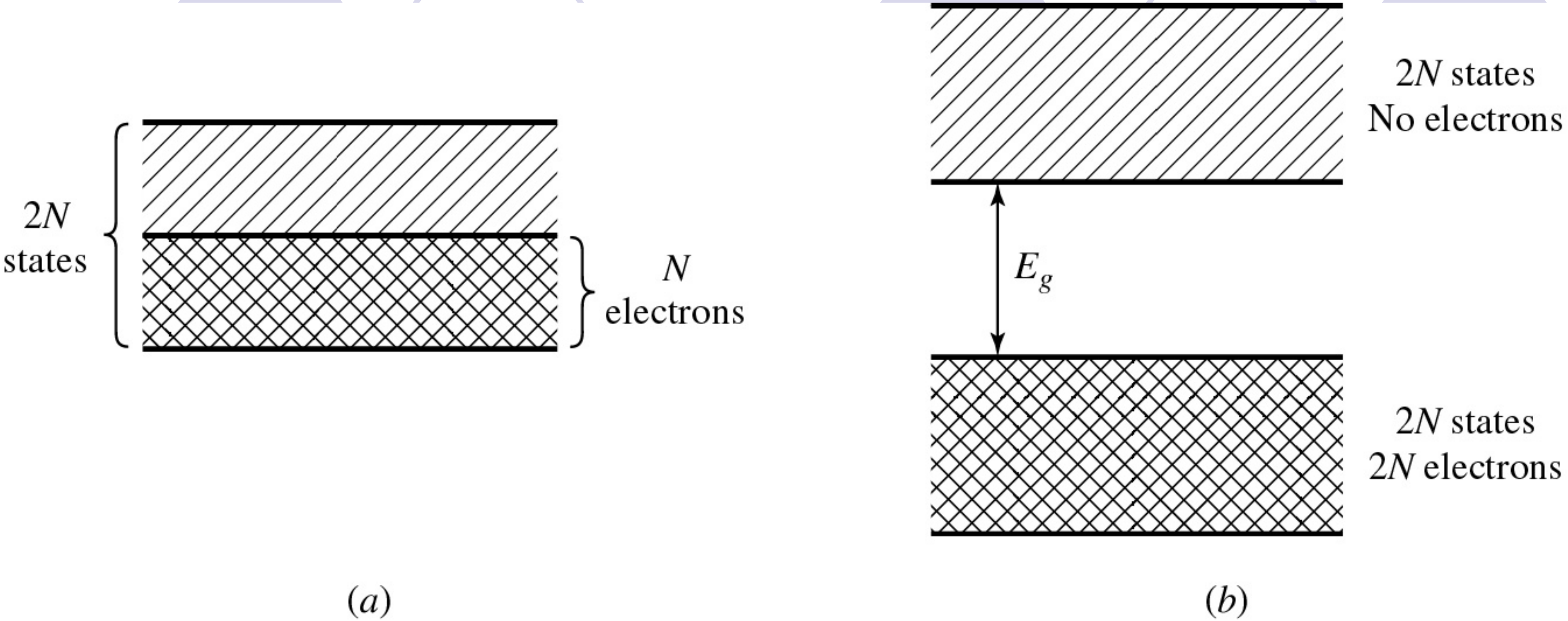

Figure 1.3 (p. 5)
Energy-band diagrams: (*a*) *N* electrons filling half of the 2*N* allowed states, as can occur in a metal. (*b*) A completely empty band separated by an energy gap E_g from a band whose 2*N* states are completely filled by 2*N* electrons, representative of an insulator.