Figure 16.31: Two-dimensional representations of (a) a quartz crystal and (b) a quartz glass.

Figure 16.28: The p orbitals (a) perpendicular to the plane of the carbon ring system in graphite can combine to form (b) an extensive pie bonding network.

The Electronic Configuration of a Magnesium Atom

<table>
<thead>
<tr>
<th>n</th>
<th>l</th>
<th>m_l</th>
<th>m_s</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>+1/2</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>-1/2</td>
</tr>
</tbody>
</table>

Mg: Ne 3s^2

Empty 3p orbitals in Mg valence shell

Orbital energy

Number of interacting atomic orbitals

Energy
Figure 16.24: A representation of the energy levels (bands) in a magnesium crystal

Figure 16.27: Partial representation of the MO energies in (a) diamond and (b) a typical metal

Electron sea model for metals

Bonding in Solids
Metallic Solids
Band structure of Semiconductors

- At $T = 0$, lower valence band is filled with electrons and upper conduction band is empty, leading to zero conductivity.
  - Fermi energy $E_F$ is at midpoint of small energy gap (<1 eV) between conduction and valence bands.
- At $T > 0$, electrons thermally “excited” from valence to conduction band, leading to measurable conductivity.

Silicon Crystal Doped with (a) Arsenic and (b) Boron

Figure 16.33: Energy-level diagrams for (a) an n-type semiconductor and (b) a p-type semiconductor.
Figure 16.34: The p-n junction involves the contact of a p-type and an n-type semiconductor.
Light Amplification by Stimulated Emission Radiation

Solar Cells

$p-n$ Junction under Illumination
A schematic of two circuits connected by a transistor.

Photolithography to make semiconductor integrated circuits

http://britneyspears.ac/physics/fabrication/photolithography.htm
(a)-(h) The steps for forming a transistor in a crystal of initially pure silicon.

![Diagram of transistor formation in pure silicon](image)

Semiconductors – key points to remember

- Band structure:
  - Valence band – gap – conduction band
- DOPING:
  - Group V → \textit{n\ type}, Group III → \textit{p\ type}
- \textit{n-p junctions}
- Devices:
  - (LED, laser, transistor, solar cell)

![Figure 16.24: A representation of the energy levels (bands) in a magnesium crystal](image)
Semiconductors – key points to remember

- Band structure:
  - Valence band – gap – conduction band

- DOPING:
  - Group V \(\rightarrow\) \textit{n type},
  - Group III \(\rightarrow\) \textit{p type}

- \textit{n-p} junctions

- Devices: (LED, laser, transistor, solar cell)

Silicon Crystal Doped with (a) Arsenic and (b) Boron

(a) \textit{n-type} semiconductor

(b) \textit{p-type} semiconductor

Band structure of Semiconductors

Energy bands, metal, insulator, semiconductor

Forbidden filled
Semiconductors – key points to remember

• Band structure:
  Valence band – gap – conduction band

• DOPING:
  Group V $\rightarrow$ n type,
  Group III $\rightarrow$ p type

• n-p junctions

• Devices:
  (LED, laser, transistor, solar cell)