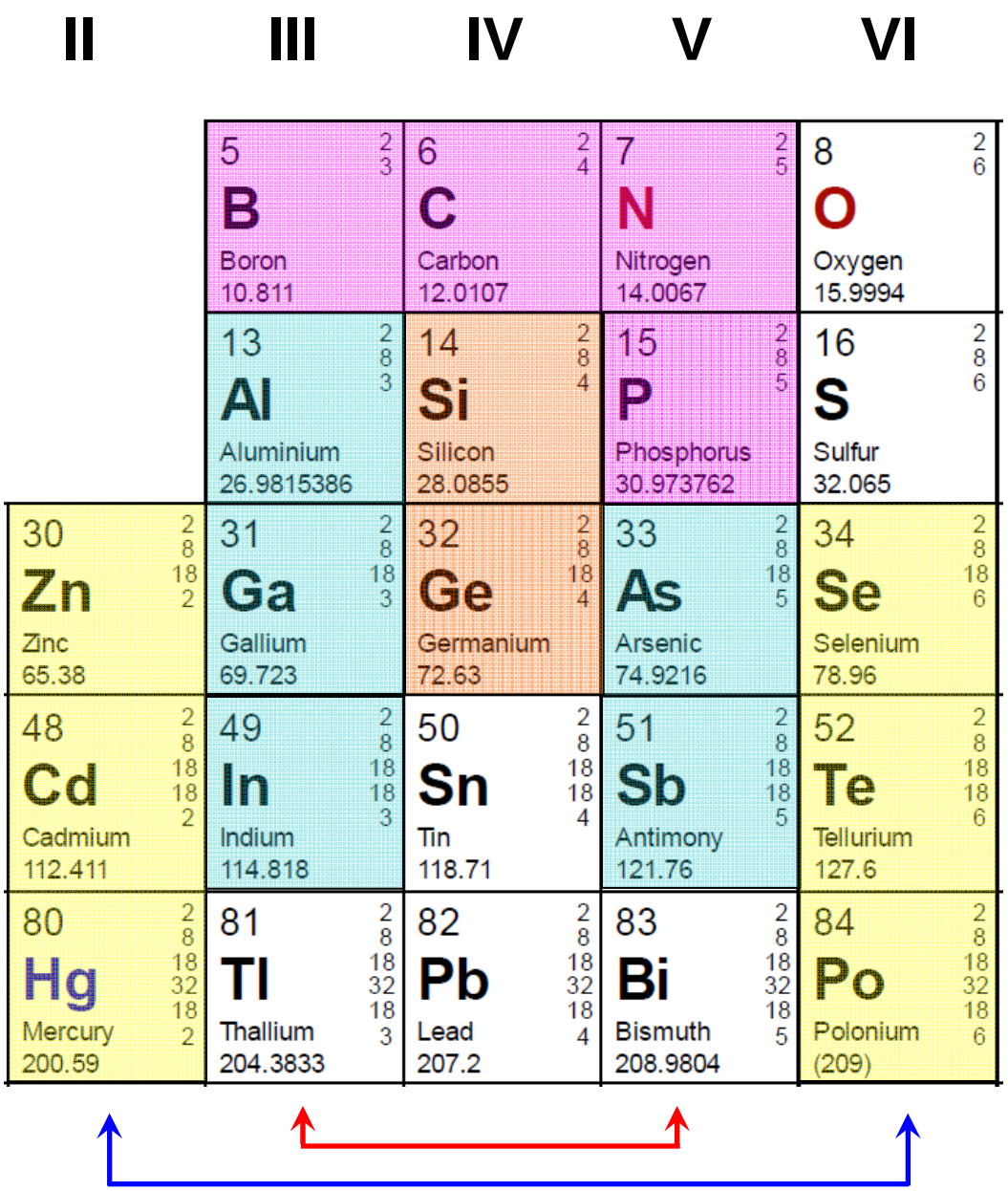
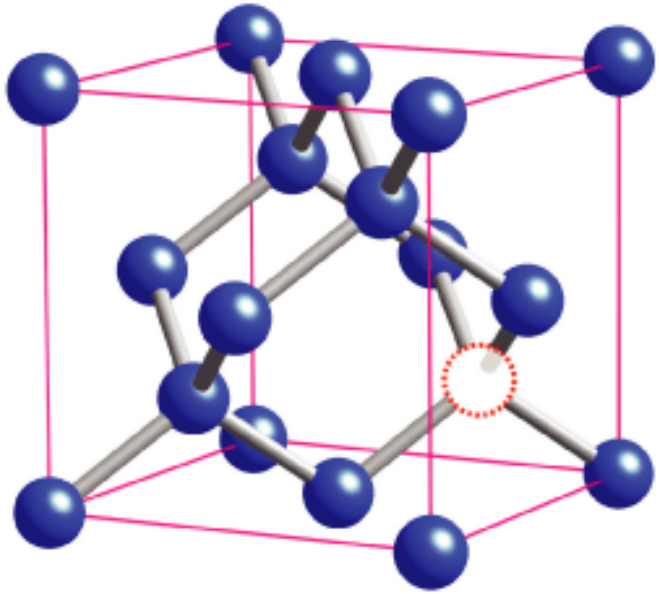

II
III
IV
V
VI
5 2 3 B Boron 10.811
6 2 4 C Carbon 12.0107
7 2 5 N Nitrogen 14.0067
8 2 6 O Oxygen 15.9994
13 2 8 3 Al Aluminium 26.9815386
14 2 8 4 Si Silicon 28.0855
15 2 8 5 P Phosphorus 30.973762
16 2 8 6 S Sulfur 32.065
30 2 8 18 2 Zn Zinc 65.38
31 2 8 18 3 Ga Gallium 69.723
32 2 8 18 4 Ge Germanium 72.63
33 2 8 18 5 As Arsenic 74.9216
34 2 8 18 6 Se Selenium 78.96
48 2 8 18 18 2 Cd Cadmium 112.411
49 2 8 18 18 3 In Indium 114.818
50 2 8 18 18 4 Sn Tin 118.71
51 2 8 18 18 5 Sb Antimony 121.76
52 2 8 18 18 6 Te Tellurium 127.6
80 2 8 18 32 18 2 Hg Mercury 200.59
81 2 8 18 32 18 3 Tl Thallium 204.3833
82 2 8 18 32 18 4 Pb Lead 207.2
83 2 8 18 32 18 5 Bi Bismuth 208.9804
84 2 8 18 32 18 6 Po Polonium (209)

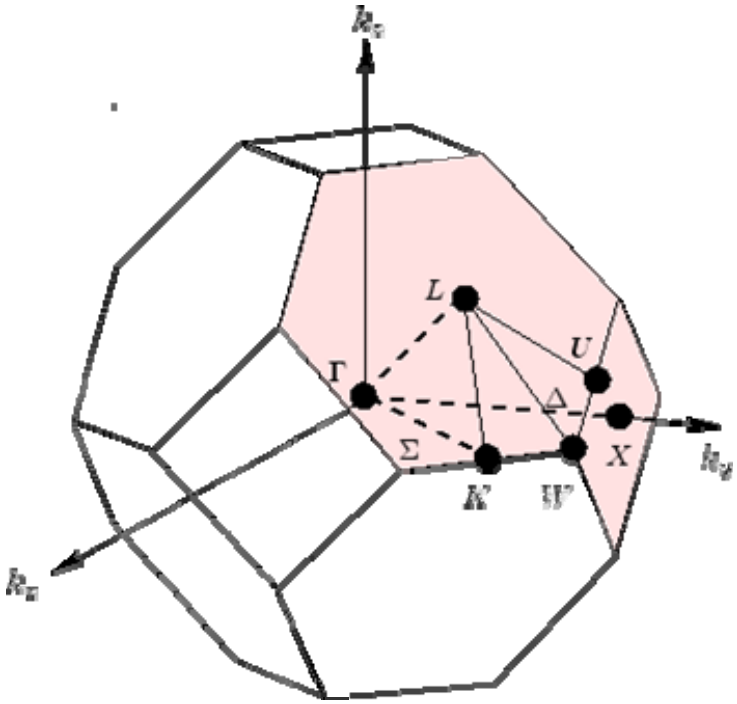
Silicone (Si)



diamond structure of Si

face centered cubic lattice
two atomic base:
(0,0,0) and (a/4, a/4, a/4)

a = 5.65 Å

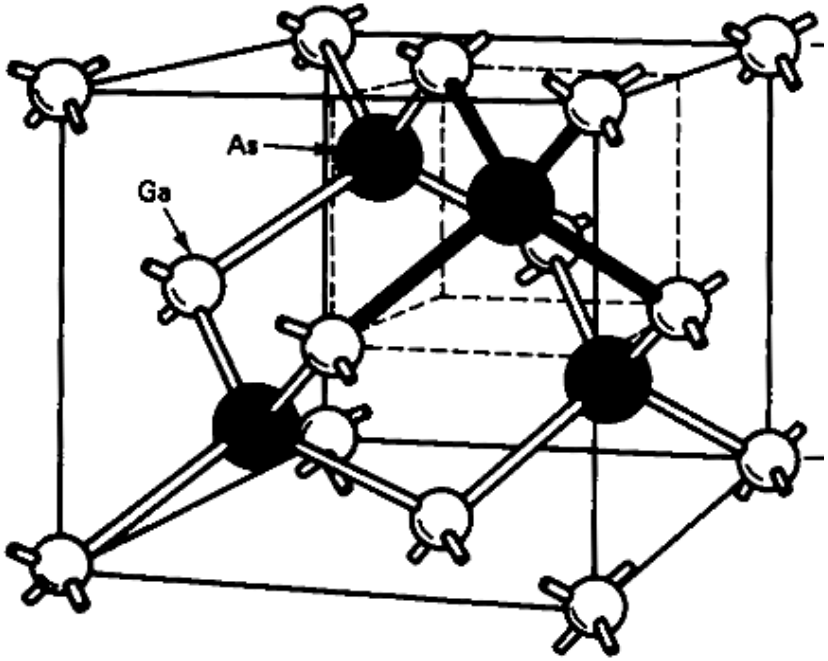


brillouin zone
(bcc)

column IV material

Ge also has diamond structure

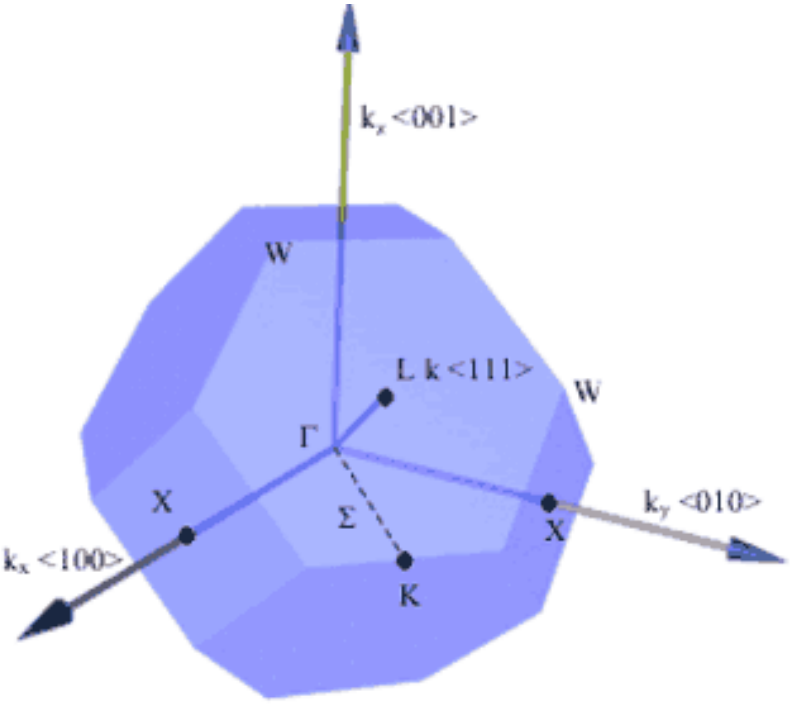
Gallium Arsenide (GaAs)



zincblende structure of GaAs

dito Si,
but one atom Ga, one As

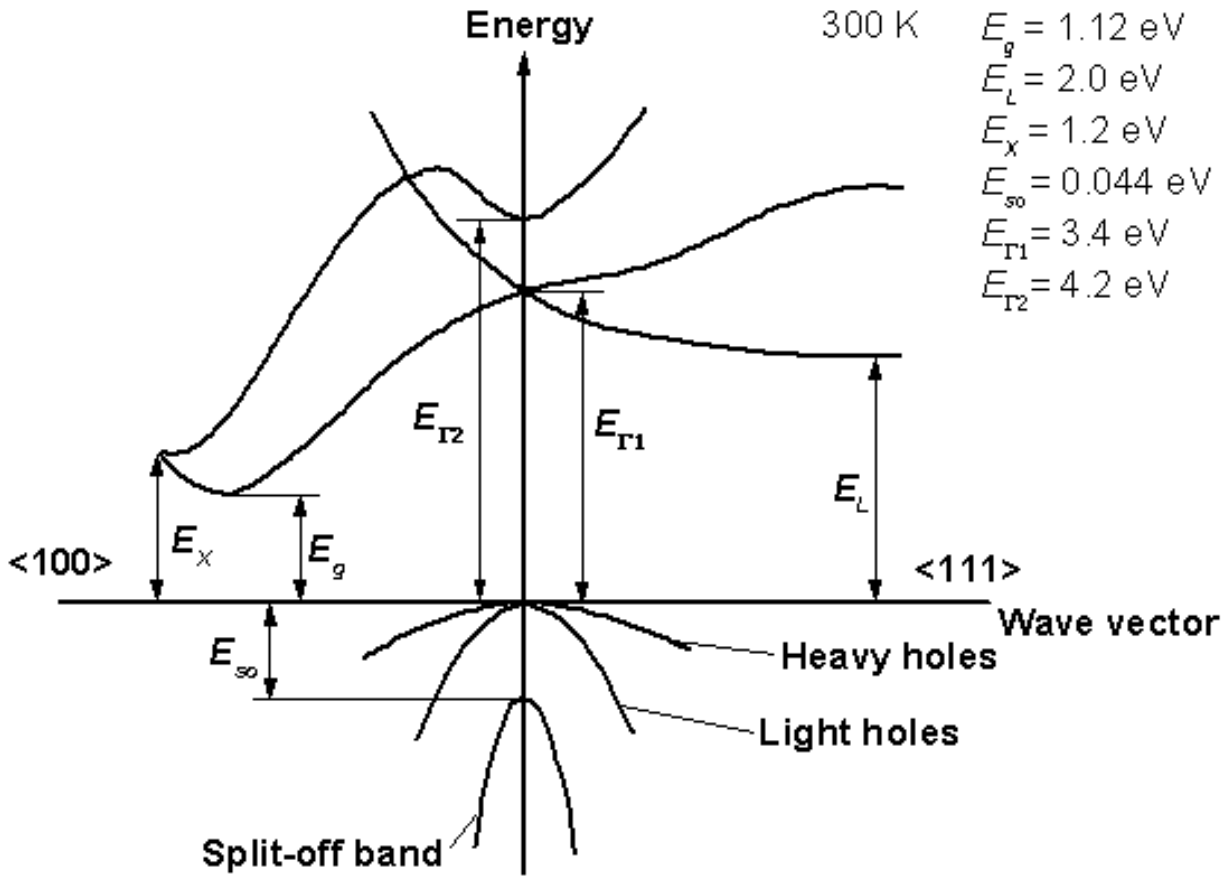
a = 5.43 Å



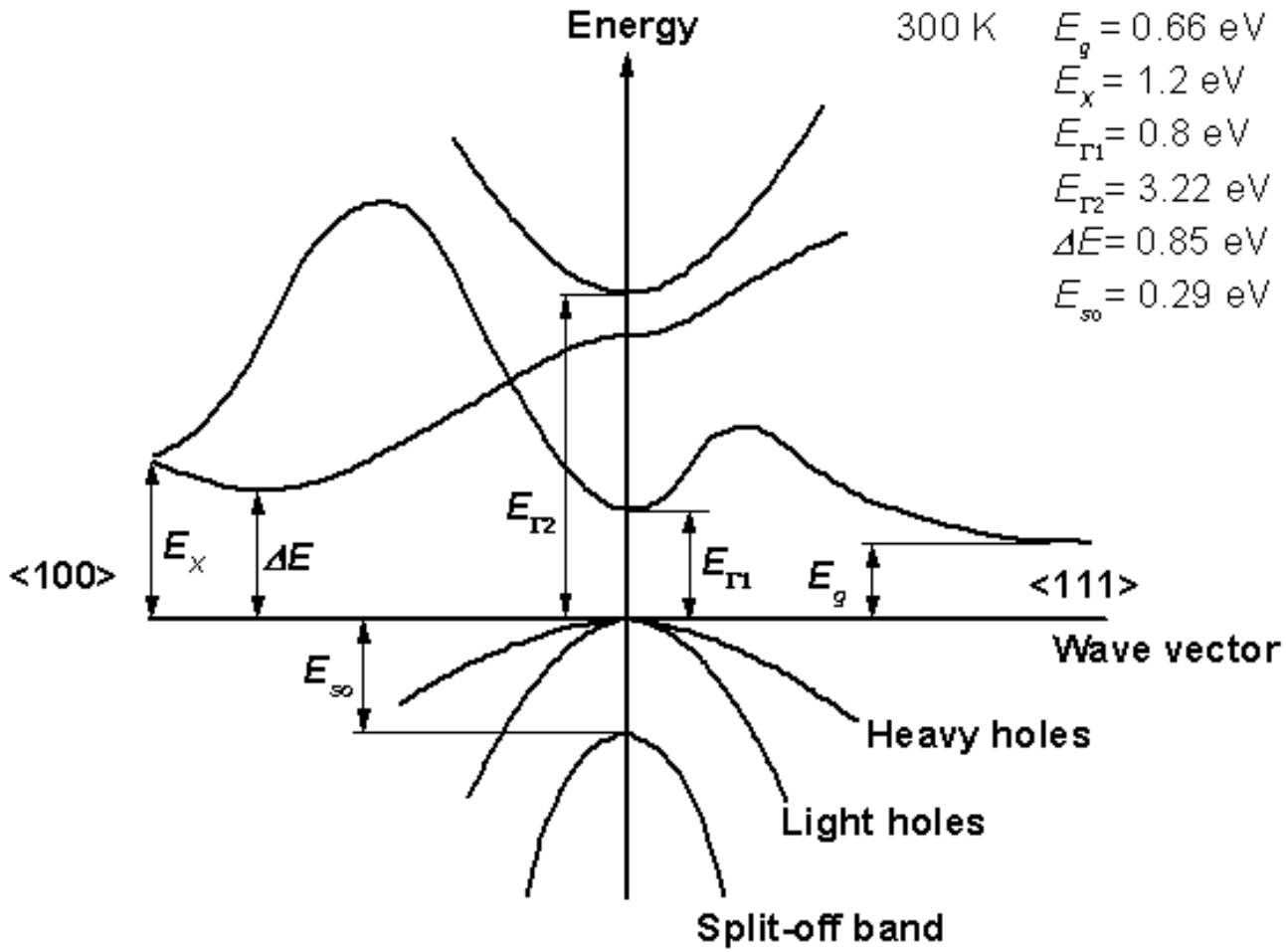
brillouin zone
(bcc)

III – V semiconductor
(binary compound)

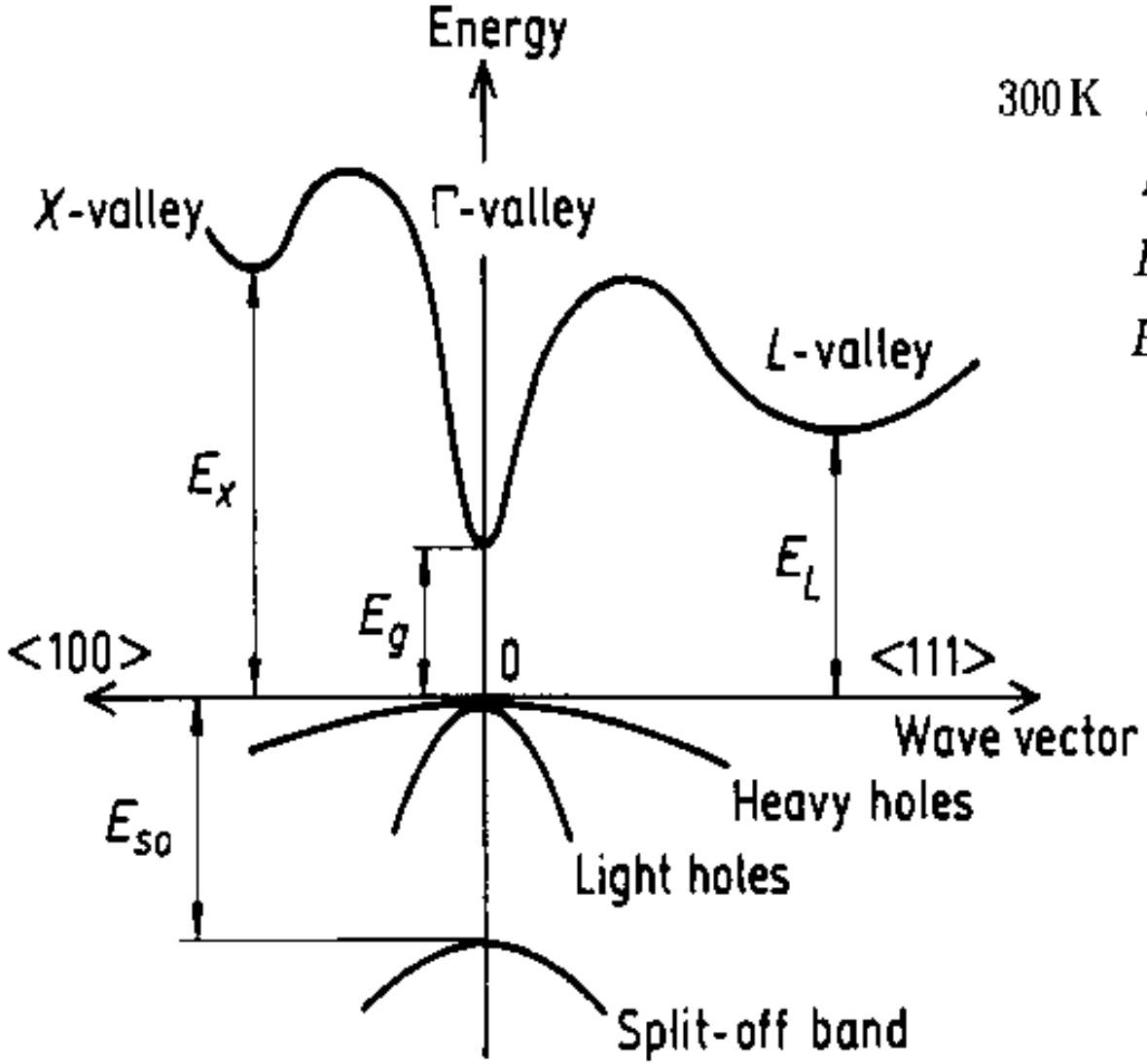
Si band structure



Ge band structure



GaAs band structure



300 K $E_g = 1.42$ eV

$E_L = 1.71$ eV

$E_X = 1.90$ eV

$E_{so} = 0.34$ eV

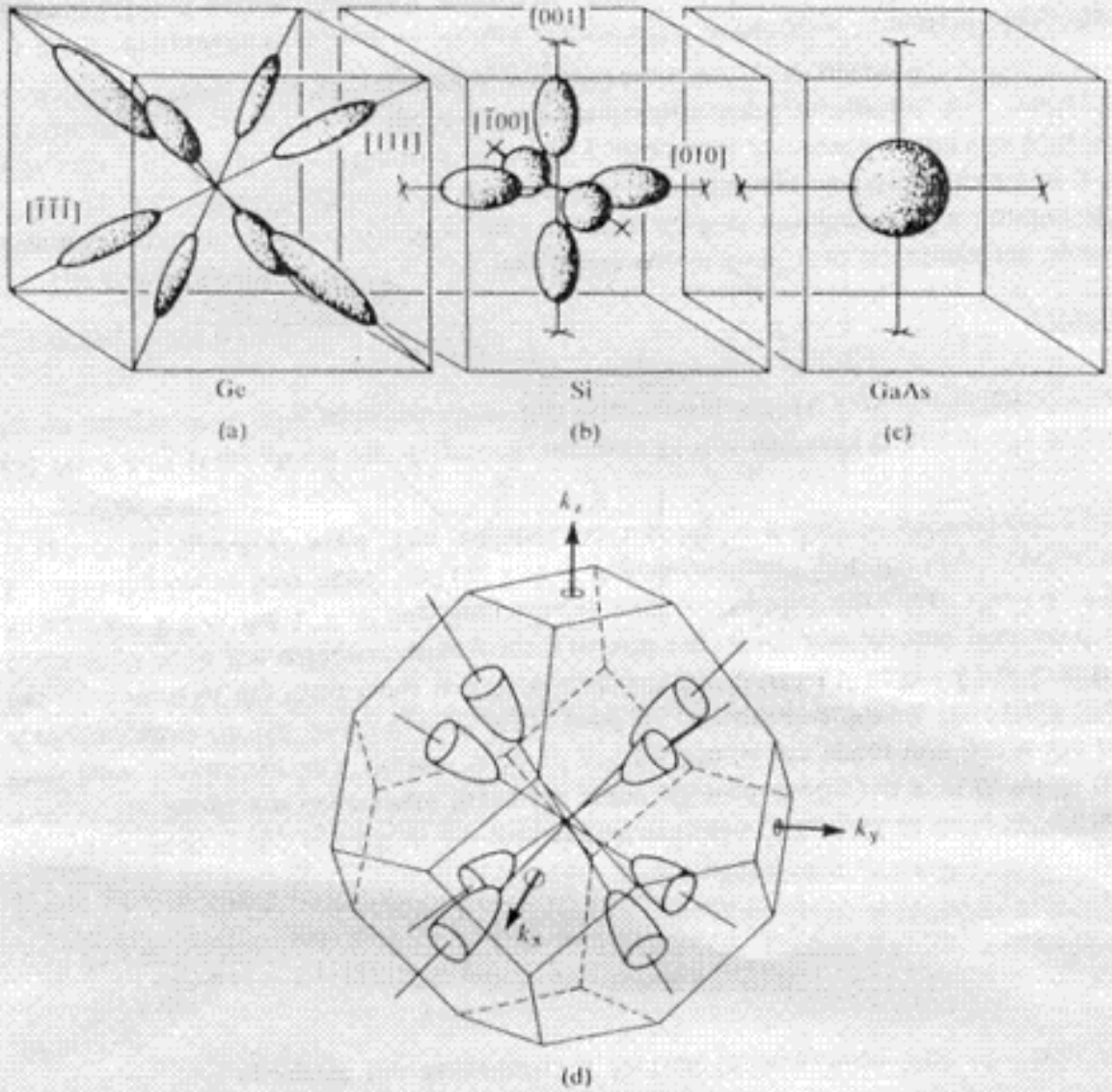
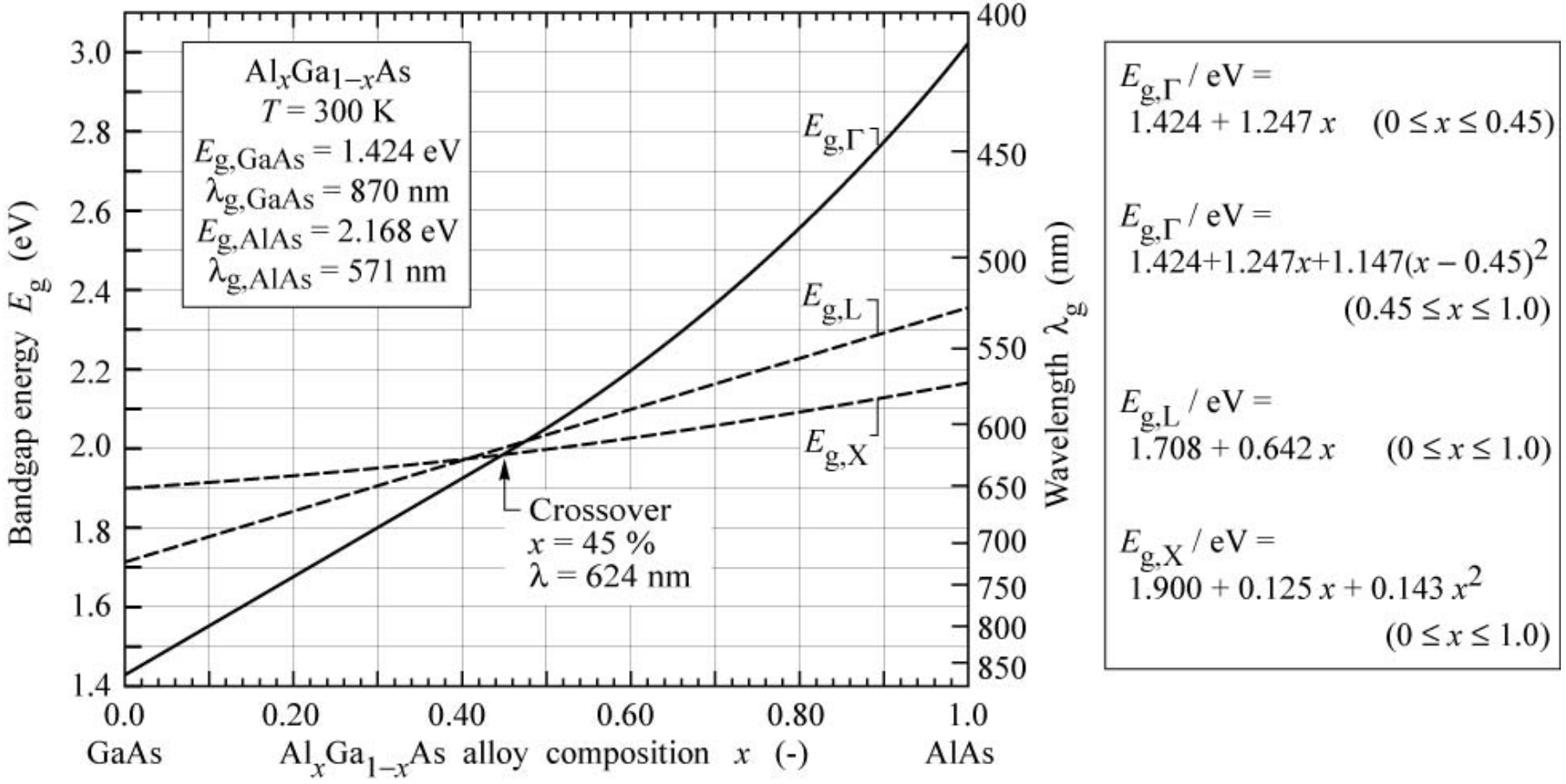


Fig. 3.14 Constant-energy surfaces characterizing the conduction-band structure in (a, d) Ge, (b) Si, and (c) GaAs. (d) shows the truncation of the Ge surfaces at the Brillouin-zone boundaries. [(a-c) after Sze[2] and Ziman;[3] (d) from McKelvey.[4] Reprinted with permission; the latter from Robert E. Krieger Publishing Co., Malabar, Florida.]



$E_{g,\Gamma}$ / eV =
$1.424 + 1.247\,x$ $\quad (0 \le x \le 0.45)$

$E_{g,\Gamma}$ / eV =
$1.424+1.247x+1.147(x-0.45)^2$
$(0.45 \le x \le 1.0)$

$E_{g,L}$ / eV =
$1.708 + 0.642\,x$ $\quad (0 \le x \le 1.0)$

$E_{g,X}$ / eV =
$1.900 + 0.125\,x + 0.143\,x^2$
$(0 \le x \le 1.0)$

Fig. 12.7. Bandgap energy and emission wavelength of AlGaAs at room temperature. E_Γ denotes the direct gap at the Γ point and E_L and E_X denote the indirect gap at the L and X point of the Brillouin zone, respectively (adopted from Casey and Panish, 1978).

Occupation of bands

electronic density of states $D_d(E)$

# of states available in a window of energy [E, E+dE].
d : dimensionality of the system

periodic boundary conditions (cube, square, line) of length L
(endresult independent of L)

$$\psi\left(\vec{r} + (L, L)\right) = \psi\left(\vec{r}\right)$$

Electronic Density of States

$$D_1(E) = \frac{g\sqrt{2m}}{2\pi\hbar}\frac{1}{\sqrt{E}}$$

$$D_2(E) = \frac{gm}{2\pi\hbar^2}$$

independent of energy

$$D_3(E) = \frac{g\,(2m)^{3/2}}{4\pi^2\hbar^3}\cdot\sqrt{E}$$