Optics of Solid-State Nanostructures (Spring 2010)

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1D Band Structure

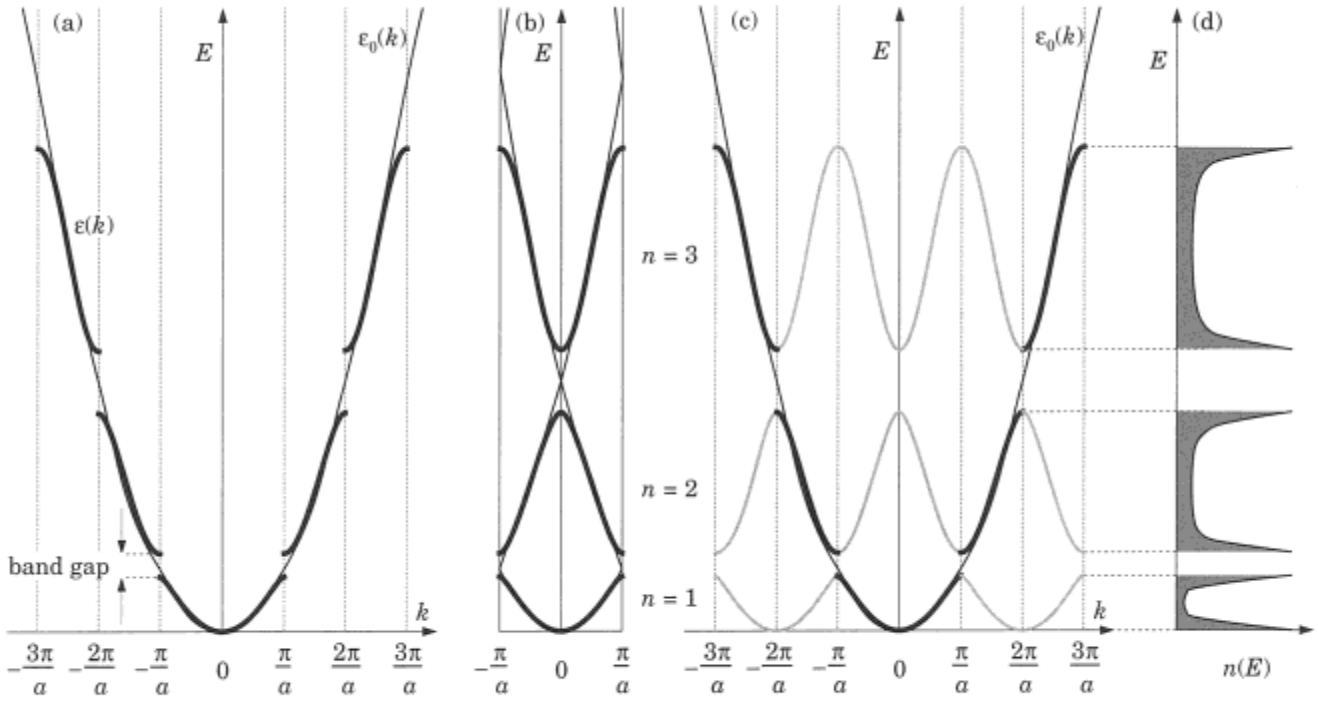

Figure 2.2. Band structure of a one-dimensional crystal in the (a) extended, (b) reduced, and (c) repeated zone schemes, and (d) the density of states as a function of energy. The thick lines show $\varepsilon(k)$ in a weak periodic potential, with bands labelled by n, while the thin parabola is $\varepsilon_0(k)$ for free electrons. The grey lines are periodic repeats.

Formation of Band-gaps

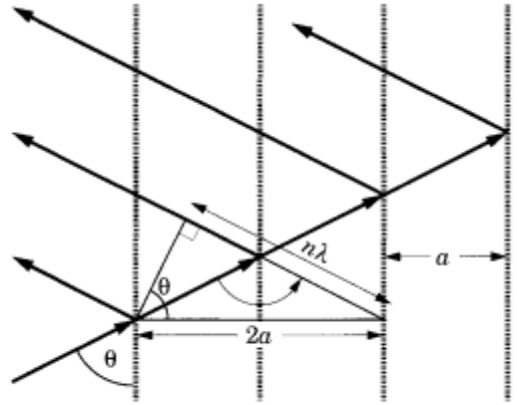

FIGURE 2.3. Condition for Bragg reflection of a wave of wavelength λ incident at angle θ onto the planes of a crystal, separated by a.

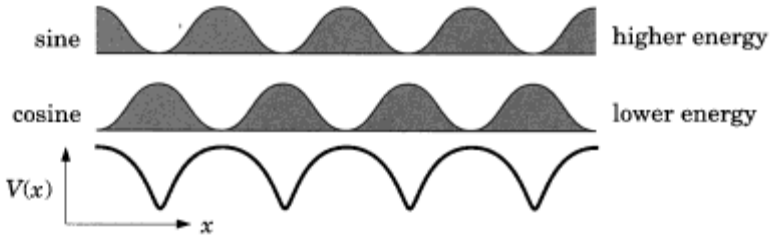

FIGURE 2.4. Periodic potential and densities associated with two wave functions at the first zone boundary $k = \pm\pi/a$.

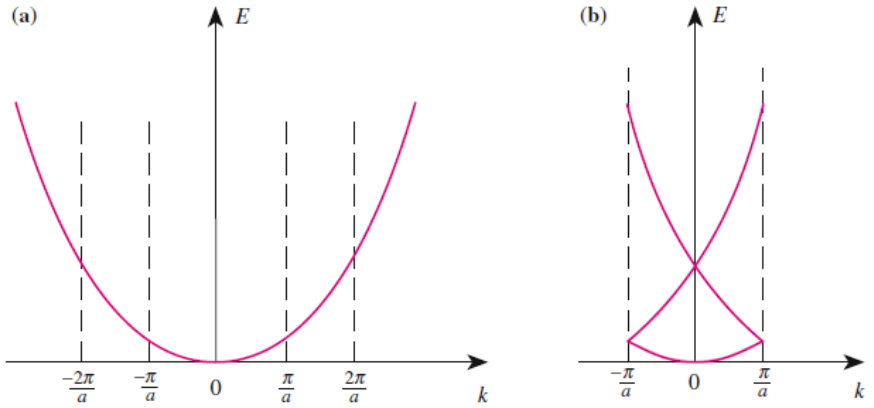

Fig. 2.1. The band structure of a free particle shown in **(a)** the extended zone scheme and **(b)** the reduced zone scheme

3D Crystals

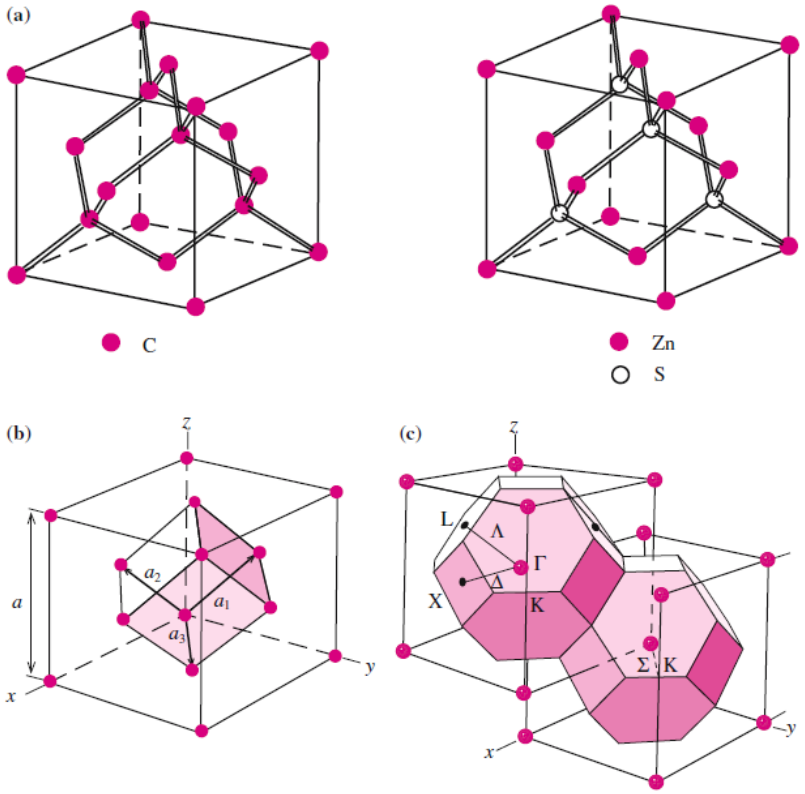

Fig. 2.2. (**a**) The crystal structure of diamond and zinc-blende (ZnS). (**b**) the fcc lattice showing a set of primitive lattice vectors. (**c**) The reciprocal lattice of the fcc lattice shown with the first Brillouin zone. Special high-symmetry points are denoted by Γ, X, and L, while high-symmetry lines joining some of these points are labeled as Λ and Δ

Free Electrons in 3D

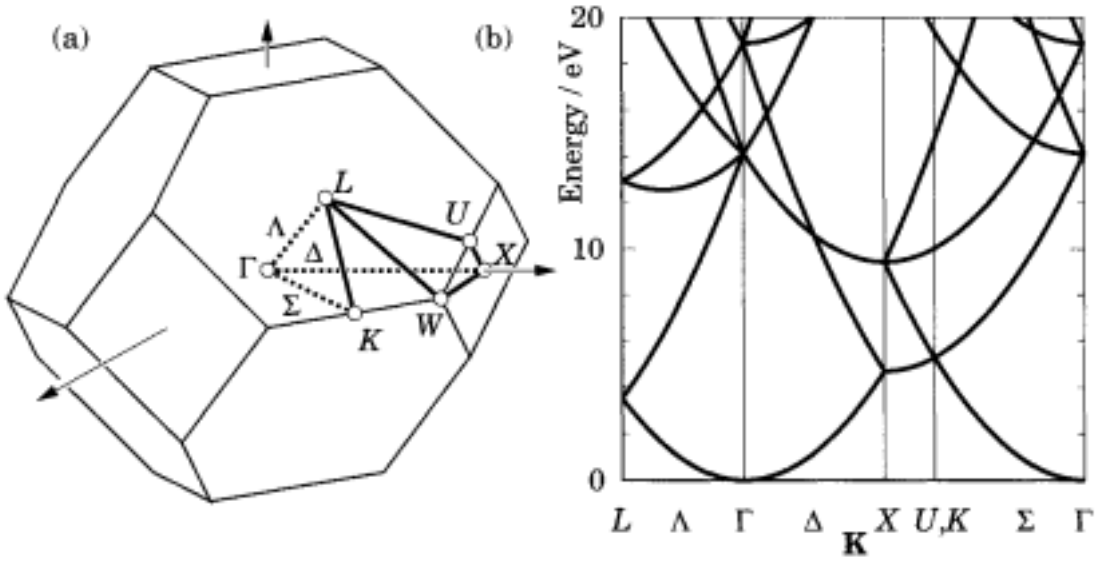

FIGURE 2.15. (a) Brillouin zone for a face-centred cubic crystal, showing the notation for special points and directions. Solid lines are on the surface with broken lines inside the zone. (b) Band structure in the free-electron model, showing the effect of folding back the parabola into the reduced zone.

Real Band-Structures

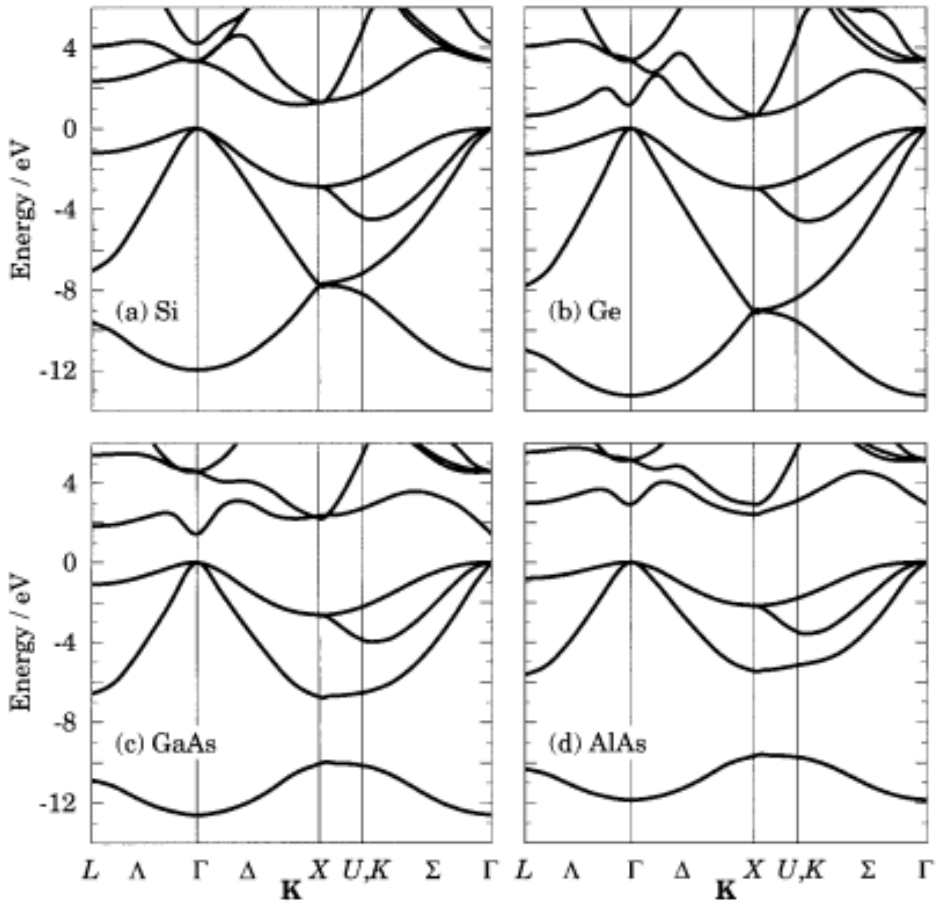

FIGURE 2.16. Band structure of four common semiconductors: silicon, germanium, gallium arsenide, and aluminium arsenide. The calculations do not include the spin–orbit coupling. [Results kindly supplied by Prof. G. P. Srivastava, University of Exeter.]

Optical Transitions

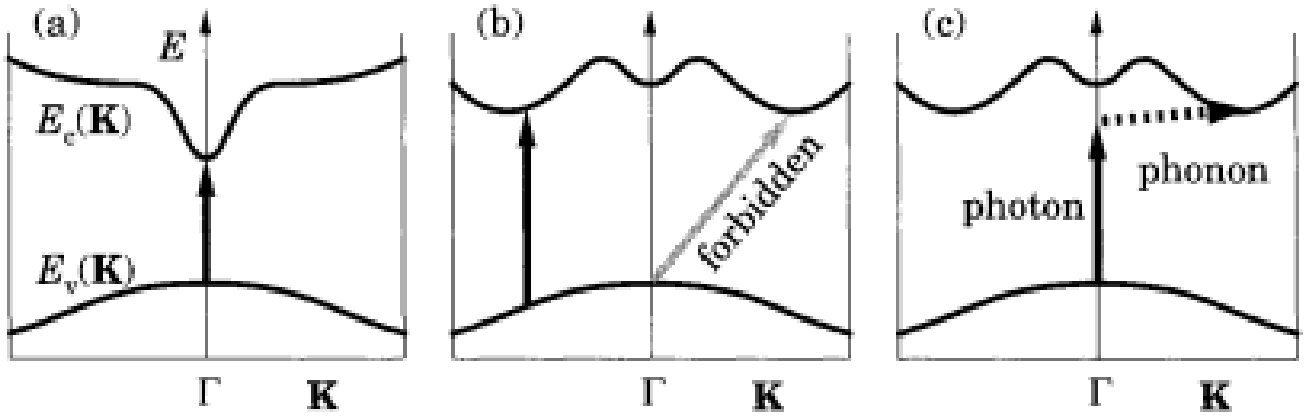

FIGURE 2.20. Optical absorption across the band gap in different types of semiconductor. (a) Absorption across a direct band gap at Γ. (b) Absorption across an indirect band gap is forbidden but vertical transitions occur for all **K**. (c) Transition across an indirect band gap with absorption of both a phonon and a photon.