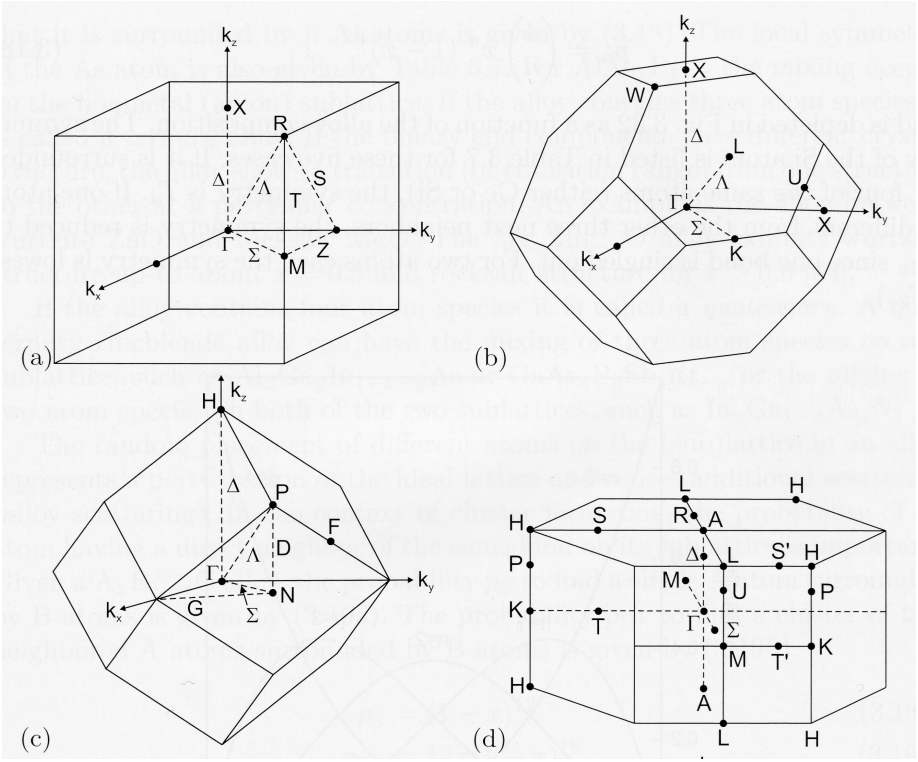
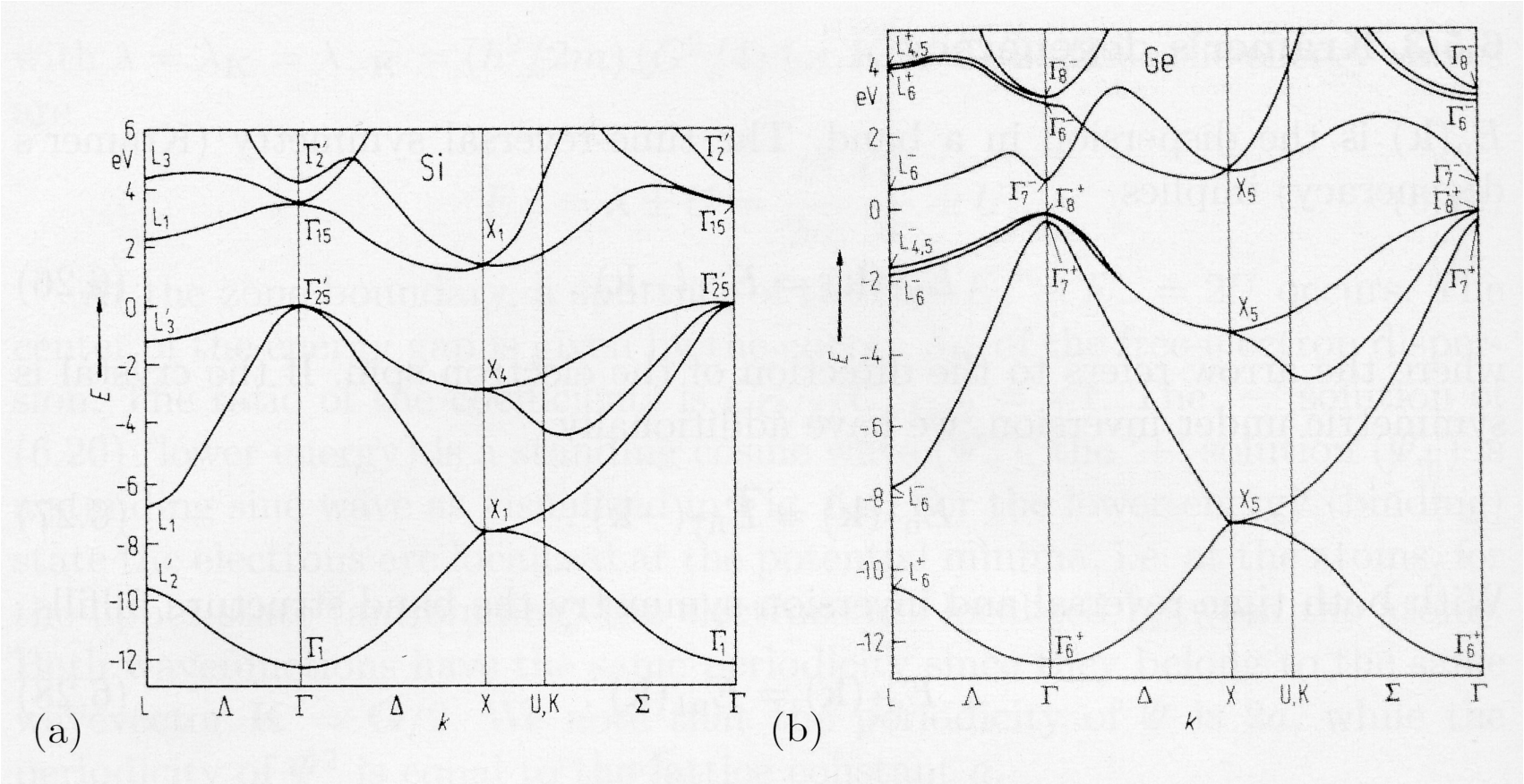
Homogeneous semiconductors

Typical band structures. Brillouin zones for the primitive cubic (a), fcc (b), bcc (c) and hcp (d) lattices.



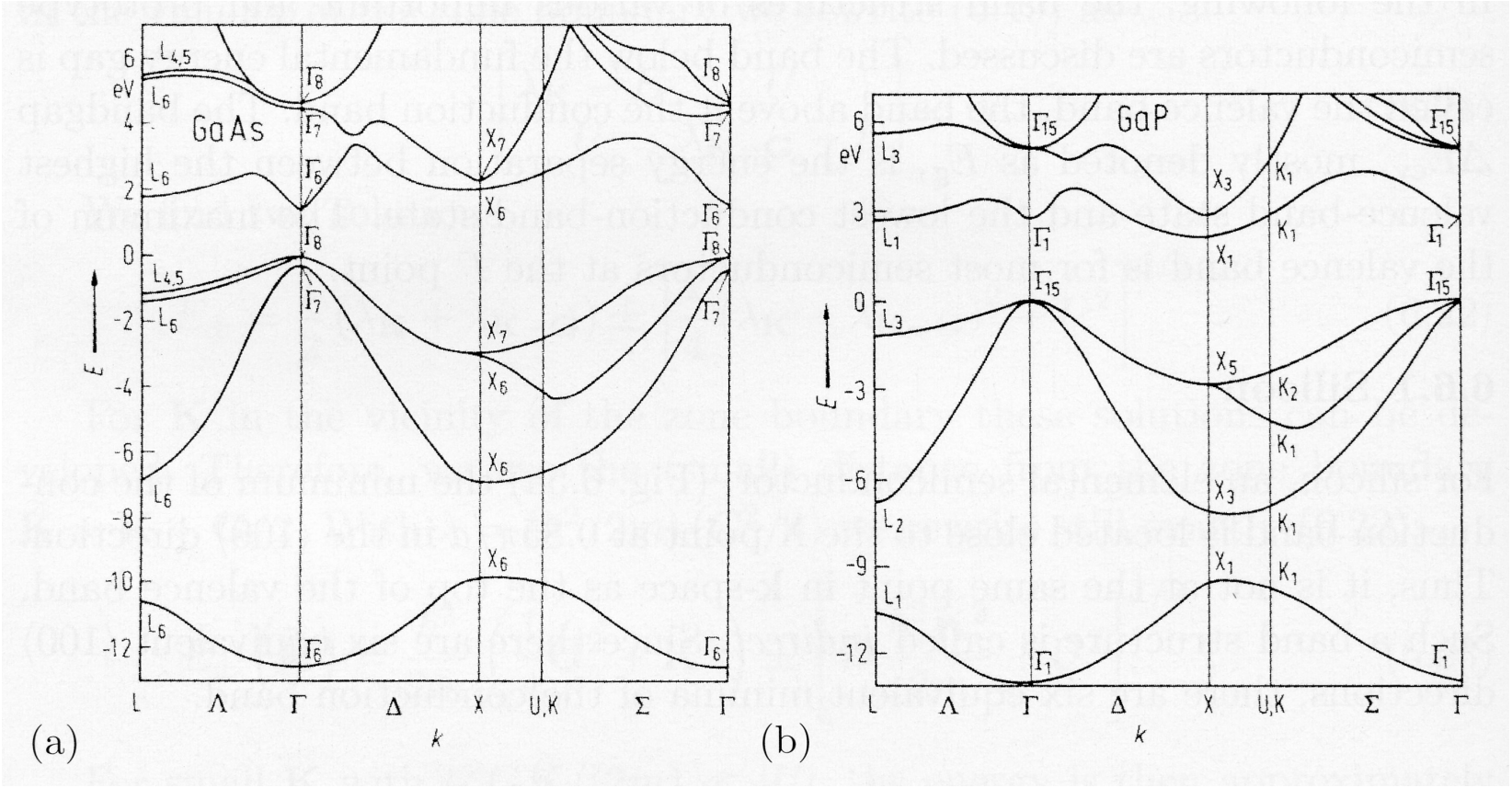
[from M. Grundmann, The Physics of Semiconductors: An Introduction Including Devices and Nanophysics (Springer, Berlin, 2006)]

Band structures of silicon and germanium; the minima of the conduction band in silicon and germanium are close to the L point and at the X point, respectively (both indirect)



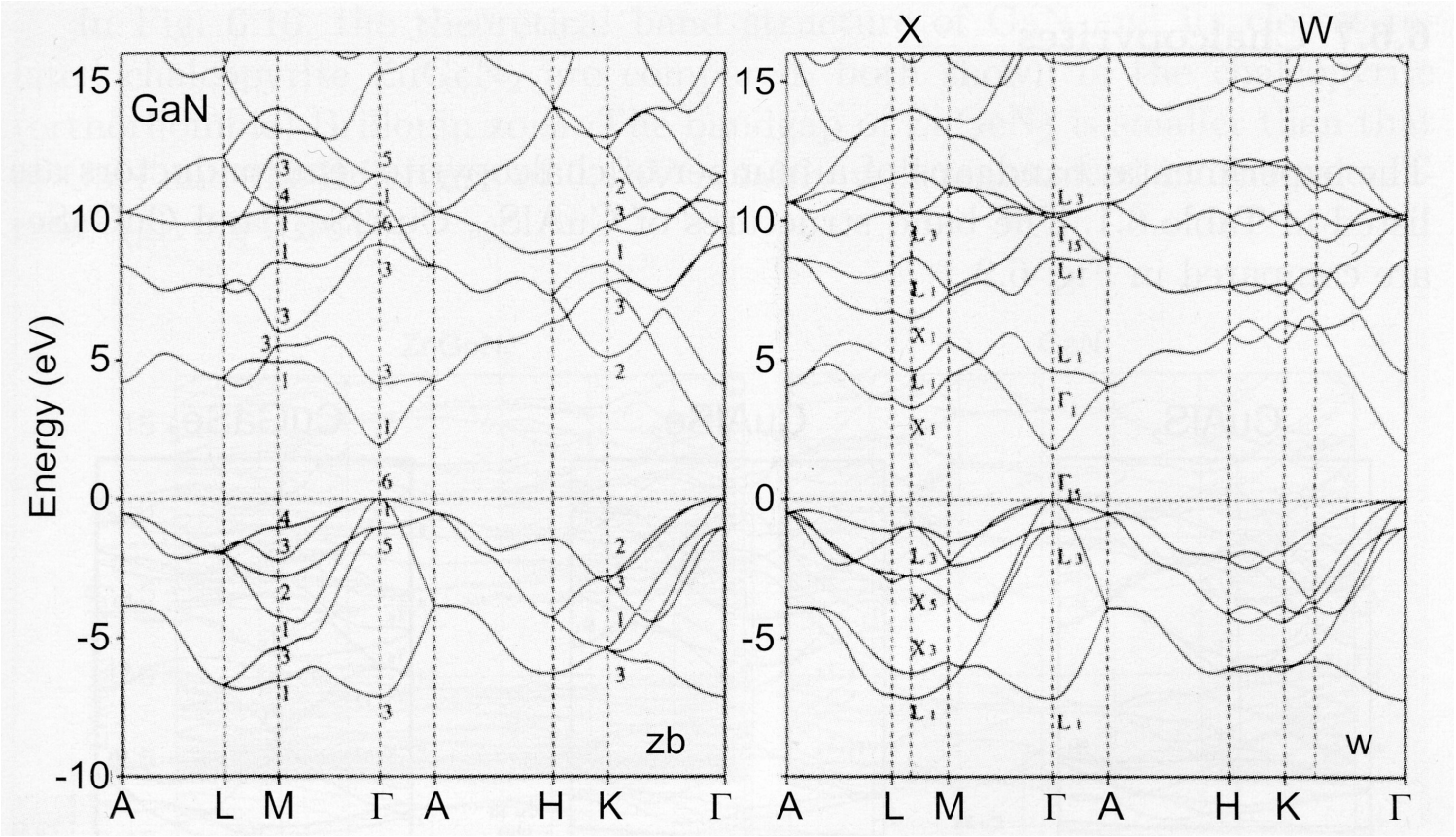
[from M. Grundmann, The Physics of Semiconductors: An Introduction Including Devices and Nanophysics (Springer, Berlin, 2006)]

Band structures of GaAs (direct) and GaP (indirect). For GaAs the minimum of the conduction band is at the Γ point; for GaP – along the [100] direction.



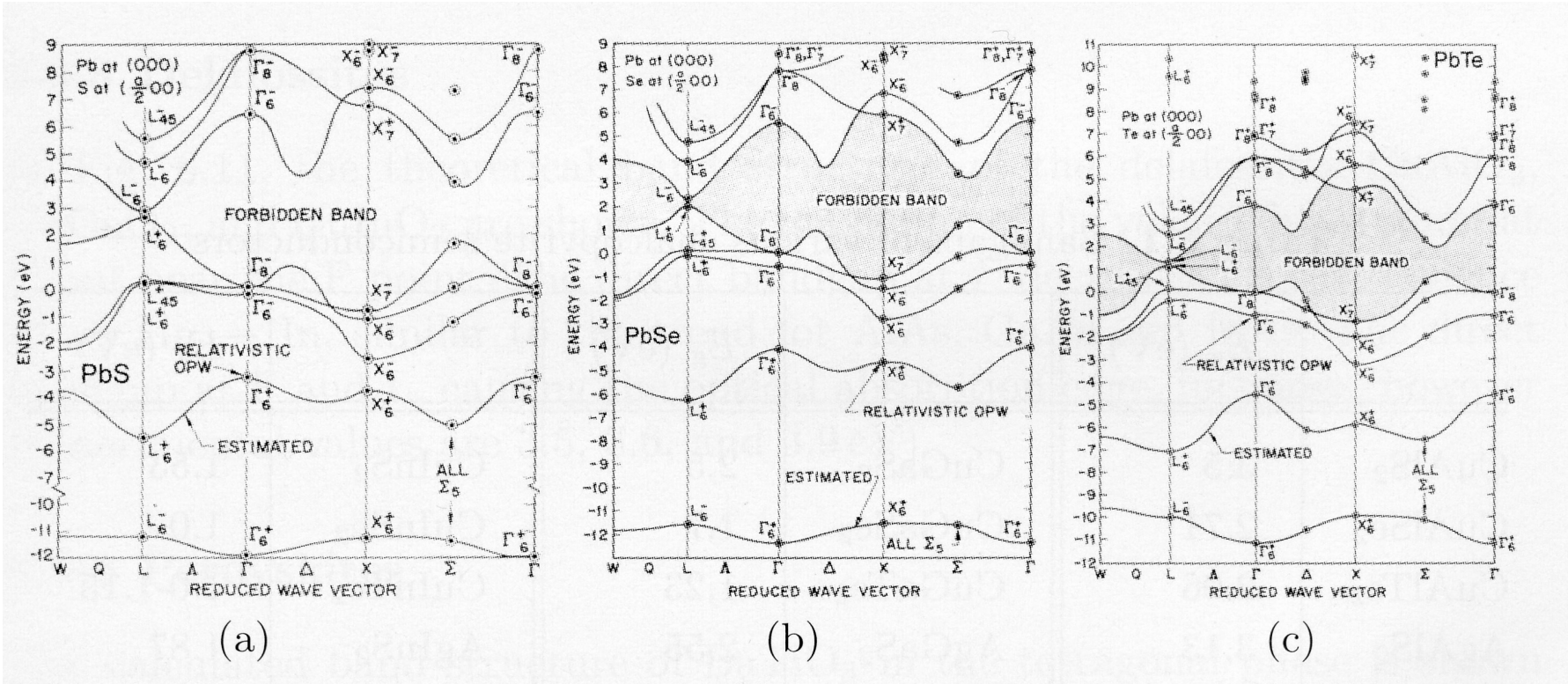
[from M. Grundmann, The Physics of Semiconductors: An Introduction Including Devices and Nanophysics (Springer, Berlin, 2006)]

Band structures of GaN (direct) in the zincblende modification (left) and wurtzite modification (right), both shown in the wurtzite BZ



[from M. Grundmann, The Physics of Semiconductors: An Introduction Including Devices and Nanophysics (Springer, Berlin, 2006)]

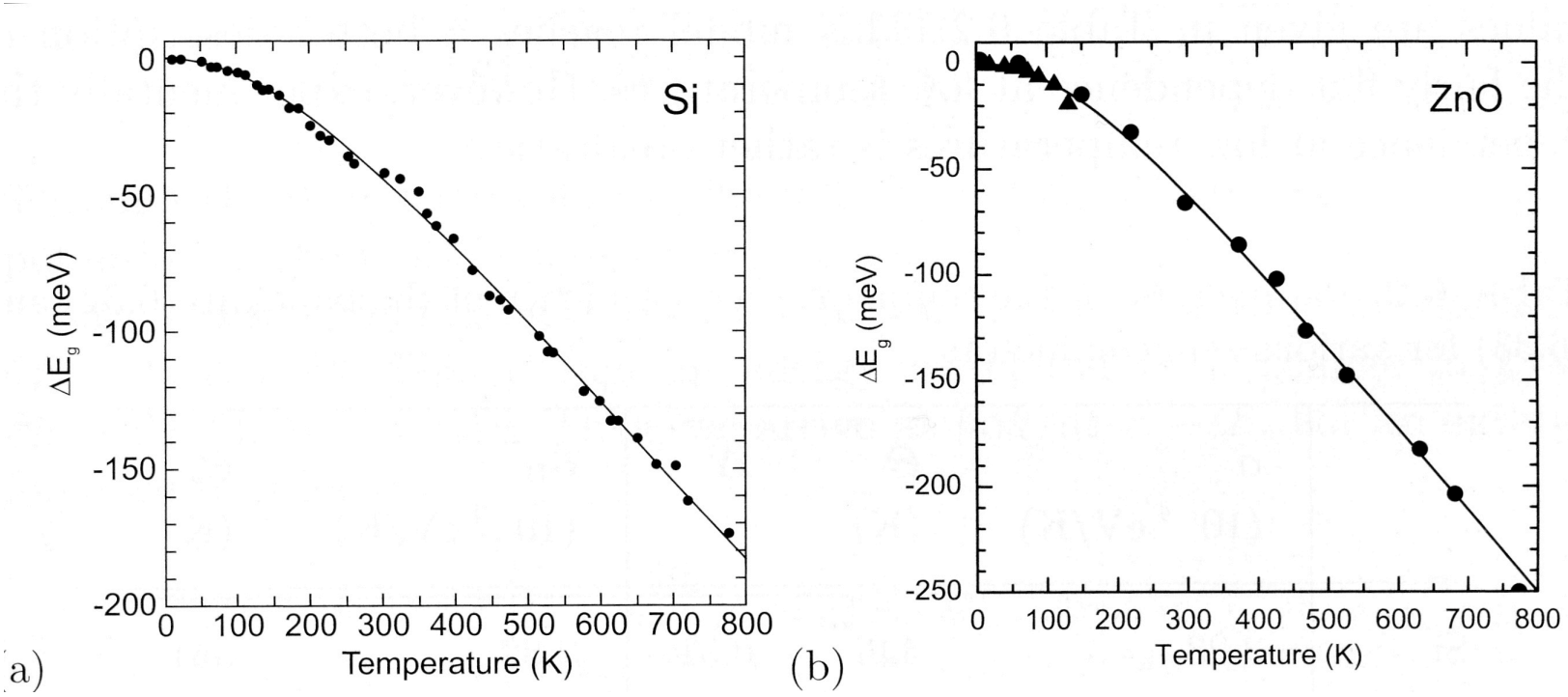
Band structures of PbS (a), PbSe (b) and PbTe (c).



[from M. Grundmann, The Physics of Semiconductors: An Introduction Including Devices and Nanophysics (Springer, Berlin, 2006)]

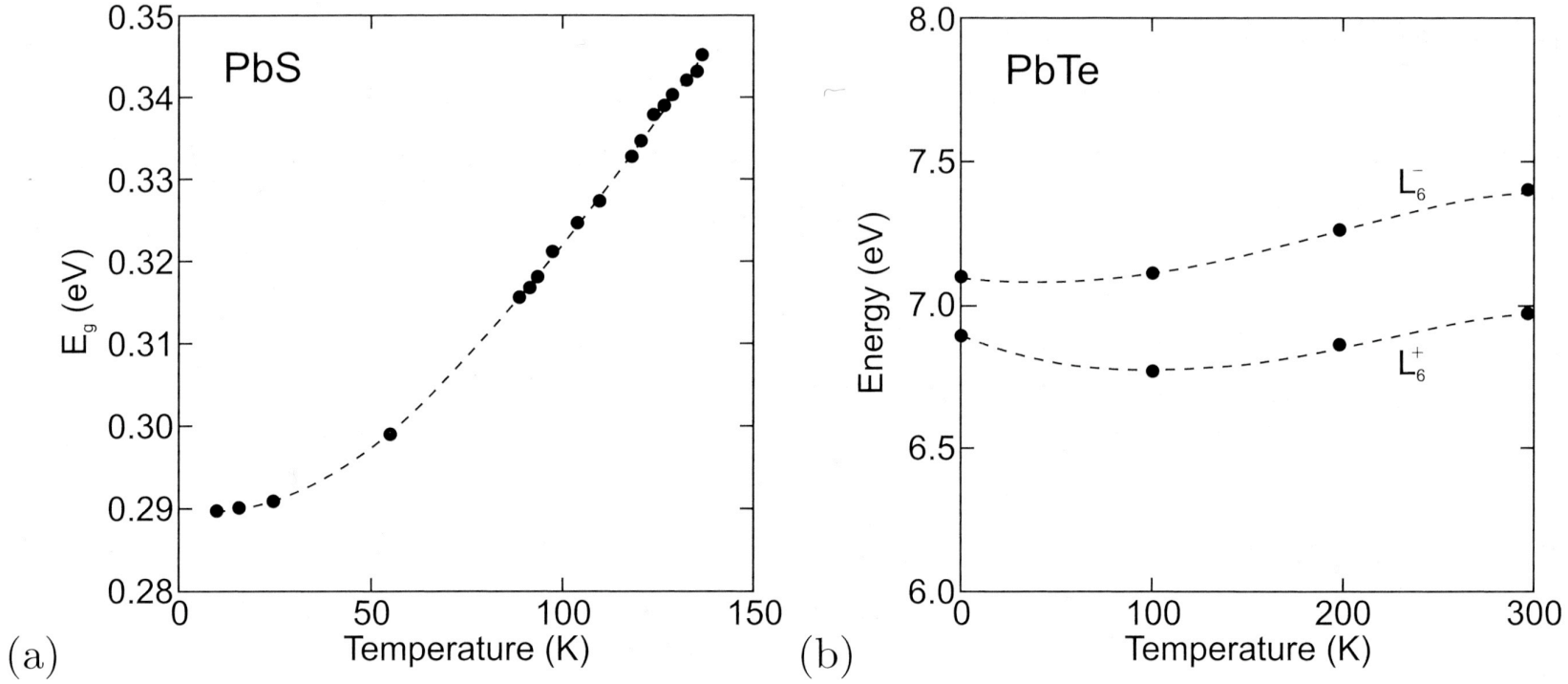
Typically, the band gap decreases with increasing temperature (lattice expansion, electron-phonon interaction)

The variation of the bandgap of Si (a) and ZnO (b); triangles – photoluminescence, circles – ellipsometry



[from M. Grundmann, The Physics of Semiconductors: An Introduction Including Devices and Nanophysics (Springer, Berlin, 2006)]

Lead chalcogenides: the $E_g(T)$ variation is anomalous:
(a) Bandgap as a function of temperature for PbS;
(b) Positions of the L_6^+ and L_6^- levels as a function of temperature for PbTe.



[from M. Grundmann, The Physics of Semiconductors: An Introduction Including Devices and Nanophysics (Springer, Berlin, 2006)]

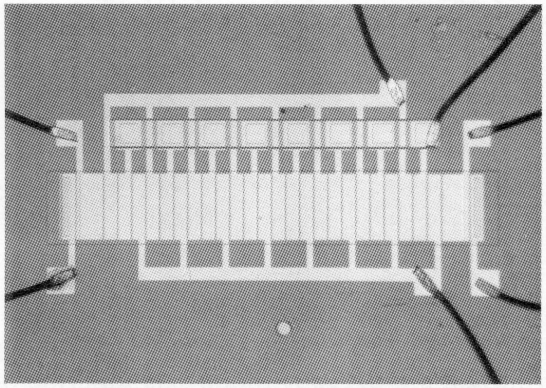
The principles of some electronic devices

Charge coupled devices (CCDs)

An array of connected photodetectors that serves as an image sensor (W. S. Boyle and G. E. Smith, 1970).

MIS diodes (silicon-based MOS diodes) designed as light detectors.

First 8-bit CCD (24 closely packed MOS capacitors):



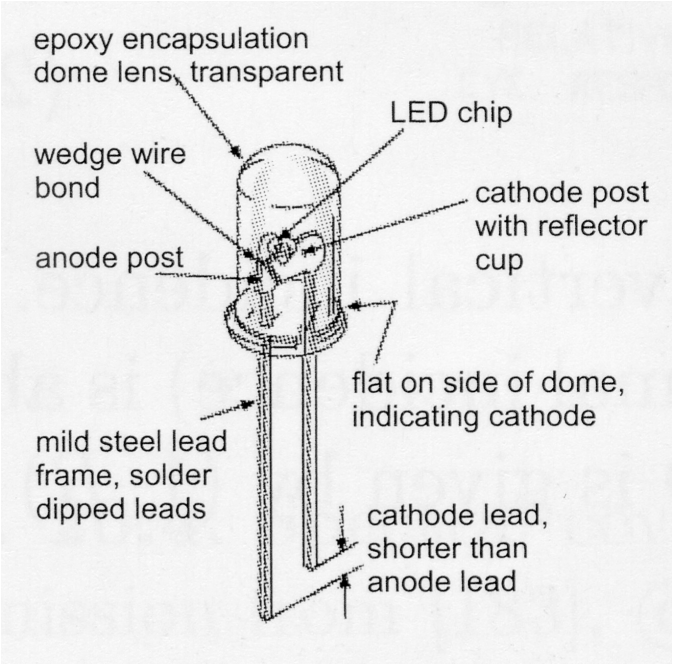
[from M. Grundmann, The Physics of Semiconductors: An Introduction Including Devices and Nanophysics (Springer, Berlin, 2006)]

Light-emitting diodes (LEDs)

Semiconductor devices in which injected carriers recombine radiatively. The recombination can be either intrinsic, or extrinsic.

The semiconductors that are currently used for the various colors of the visible spectrum are

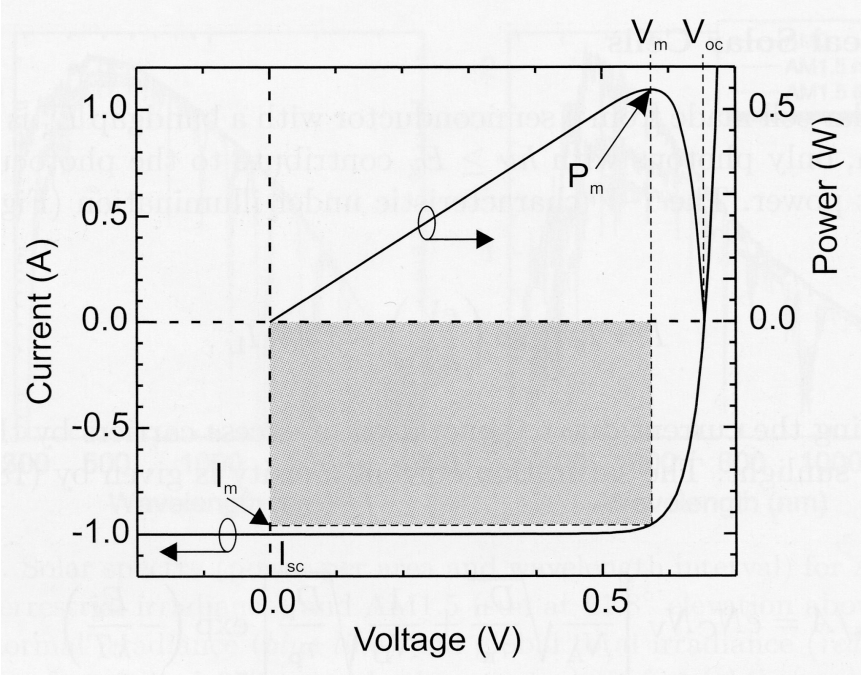
red-yellow: GaAsP/GaAs,
AlInGaP/GaP
yellow-green: GaP:N
green-blue: SiC, GaN, InGaN
violet: GaN
ultraviolet: AlGaN



[from M. Grundmann, The Physics of Semiconductors: An Introduction Including Devices and Nanophysics (Springer, Berlin, 2006)]

Solar cells

Schematic *I–V* characteristics of a solar cell under illumination (left scale) and extracted power (right scale). The shaded area is the maximum power rectangle.



[from M. Grundmann, The Physics of Semiconductors: An Introduction Including Devices and Nanophysics (Springer, Berlin, 2006)]