Class 04
Charge density in intrinsic semiconductors

25.02.2025

- ❑ Fermi-Dirac distribution and Fermi energy
- ❑ Carrier Statistics
- ❑ Charge density engineering
    - Effect of band gap
    - Effect of dimensionality
    - Effect of temperature
    - Effect of electric field
    - Effect of confinement

Impact of **temperature** on the carrier density

$$n_i = p_i = \sqrt{N_V N_C} \exp\left(-\frac{E_g}{2kT}\right)$$

The bandgap also varies with T due to a different electron-phonon interaction and the variation of the interatomic distance.

How does the band gap change with increasing T?

- Larger BG
- Same BG (negligible effect)
- Smaller BG

Which factor is dominant for the n_i?

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$$E_g(T) = E_g(0) - \frac{\alpha T^2}{T + \beta},$$

Varshni Formula
Grundmann Ch 6.7

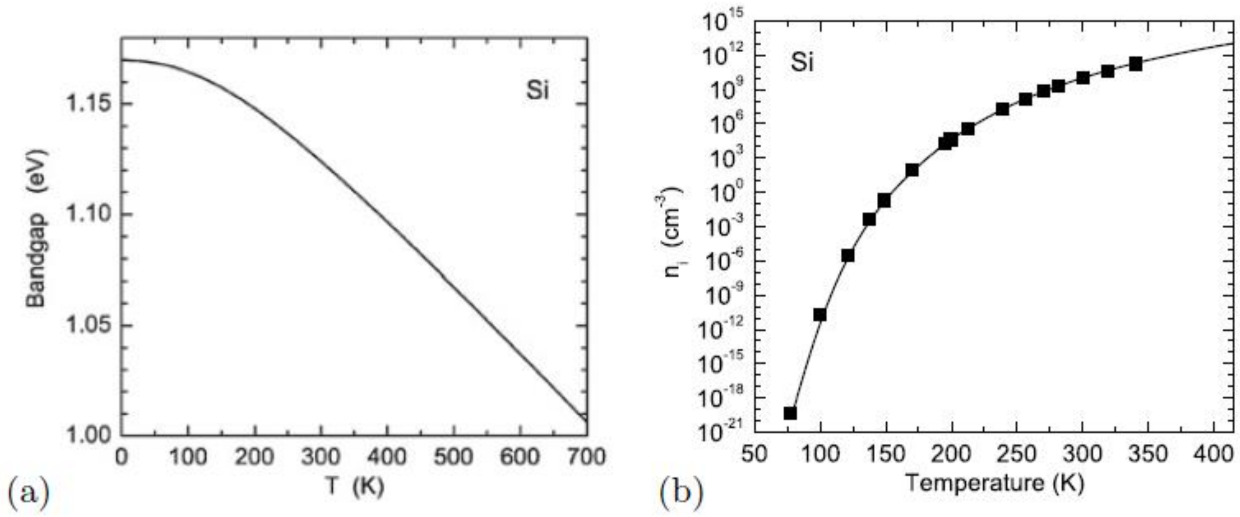

Fig. 7.3 **a** Band gap of silicon versus temperature. **b** Intrinsic carrier concentration of silicon versus temperature. *Solid line* is (7.17) using $E_g = 1.204\,\text{eV} - (2.73 \times 10^{-4}\,\text{eV/K})\,T$ [564], *symbols* are experimental data from [565]

Grundmann, Chapter 6.7