Halfgeleiders

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Intrinsic

Assumptions

- Fermi-Dirac distribution
- Density of States
- Maxwell-Boltzmann approximation for Fermi-Dirac distribution if $E - E_F > 3kT$
- Charge neutrality: $n = p$

Conclusions

- $n = N_C \exp\left(\frac{E_F - E_C}{kT}\right)$
- $p = N_V \exp\left(\frac{E_V - E_F}{kT}\right)$
- $n_i \triangleq n = p$
- $n = p \Rightarrow E_F = E_i \triangleq \frac{E_C + E_V}{2} + \frac{kT}{2} \ln\left(\frac{N_V}{N_C}\right)$

Extrinsic

Assumptions

- $n = N_D$ (n-type)
- $p = N_A$ (p-type)
- Charge neutrality: $n + N_A = p + N_D$

Conclusions

- $n = N_D = N_C \exp\left(\frac{E_F - E_C}{kT}\right) \Rightarrow E_F - E_C = kT \ln\left(\frac{N_D}{N_C}\right)$ (n-type)
- $p = N_A = N_V \exp\left(\frac{E_V - E_F}{kT}\right) \Rightarrow E_V - E_F = kT \ln\left(\frac{N_A}{N_C}\right)$ (p-type)
- $n = N_C \exp\left(\frac{E_F - E_C}{kT}\right) = N_C \exp\left(\frac{E_F - E_i + E_i - E_C}{kT}\right) = n_i \exp\left(\frac{E_F - E_i}{kT}\right)$
- $p = N_V \exp\left(\frac{E_V - E_F}{kT}\right) = N_V \exp\left(\frac{E_V - E_i + E_i - E_F}{kT}\right) = n_i \exp\left(\frac{E_i - E_F}{kT}\right)$
- $n \cdot p = n_i \exp\left(\frac{E_F - E_i}{kT}\right) \cdot n_i \exp\left(\frac{E_i - E_F}{kT}\right) = n_i^2$
- $n_n = \frac{N_D - N_A}{2} + \frac{\sqrt{(N_D - N_A)^2 + 4n_i^2}}{2} \approx N_D - N_A$ (n-type)
- $p_p = \frac{N_A - N_D}{2} + \frac{\sqrt{(N_A - N_D)^2 + 4n_i^2}}{2} \approx N_A - N_D$ (p-type)

Formularium