# Halfgeleiders

### Intrinsic

#### Assumptions

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

#### Conclusions

- $egin{aligned} ullet & n = N_C \exp\left(rac{E_F E_C}{kT}
  ight) \ ullet & p = N_V \exp\left(rac{E_V E_F}{kT}
  ight) \end{aligned}$
- $ullet n_i riangleq n = p$
- $ullet \quad n=p\Rightarrow E_F=E_i riangleqrac{E_C+E_V}{2}+rac{kT}{2}\ln\left(rac{N_V}{N_C}
  ight)$

## **Extrinsic**

## **Assumptions**

- $n=N_D$  (n-type)
- $ullet p = N_A ext{ (p-type)}$
- Charge neutrality:  $n+N_A=p+N_D$

#### Conclusions

- $ullet n=N_D=N_C\exp\left(rac{E_F-E_C}{kT}
  ight)\Rightarrow E_F-E_C=kT\ln\left(rac{N_D}{N_C}
  ight)$  (n-type)
- ullet  $p=N_A=N_V\exp\left(rac{E_V-E_F}{kT}
  ight)\Rightarrow E_V-E_F=kT\ln\left(rac{N_A}{N_C}
  ight)$  (p-type)
- $n = N_C \exp\left(\frac{E_F E_C}{kT}\right) = N_C \exp\left(\frac{E_F E_i + E_i E_C}{kT}\right) = n_i \exp\left(\frac{E_F E_i}{kT}\right)$   $p = N_V \exp\left(\frac{E_V E_F}{kT}\right) = N_V \exp\left(\frac{E_V E_i + E_i E_F}{kT}\right) = n_i \exp\left(\frac{E_i E_F}{kT}\right)$
- $ullet n \cdot p = n_i \exp\left(rac{E_F E_i}{kT}
  ight) \cdot n_i \exp\left(rac{E_i E_F}{kT}
  ight) = n_i^2$
- $egin{align*} ullet & n_n = rac{N_D N_A}{2} \, + \, rac{\sqrt{(N_D N_A)^2 + 4n_i^2}}{2} & pprox N_D N_A ext{ (n-type)} \ ullet & p_p = rac{N_A N_D}{2} \, + \, rac{\sqrt{(N_A N_D)^2 + 4n_i^2}}{2} & pprox N_A N_D ext{ (p-type)} \ \end{pmatrix}$

## Formularium