Important Semiconductor Carriers Formulas PDF

Formulas
Examples
with Units

List of 15
Important Semiconductor Carriers Formulas

1) Carrier Lifetime Formula

Evaluate Formula

Formula

$$T_a = \frac{1}{\alpha_r \cdot \left(p_0 + n_0 \right)}$$

Example with Units

$$3.6\text{E-}6\,\text{s} = \frac{1}{1.2\text{e-}6\,\text{m}^3/\text{s} \cdot \left(2.3\text{e}11\,1/\text{m}^3 + 1.4\text{e}7\,1/\text{m}^3 \right)}$$

2) Conduction Band Energy Formula

Evaluate Formula

Formula

$$E_c = E_g + E_v$$

Example with Units

$$17.5\,\text{eV} = 0.198\,\text{eV} + 17.302\,\text{eV}$$

3) Distribution Coefficient Formula

Evaluate Formula

Formula

$$k_d = \frac{C_{solid}}{C_L}$$

Example with Units

$$0.404 = \frac{1.01\text{e}15\,\text{cm}^{-1}}{2.5\text{e}15\,\text{cm}^{-1}}$$

4) Effective Density State in Valence Band Formula

Evaluate Formula

Formula

$$N_v = \frac{p_0}{1 - f_E}$$

Example with Units

$$2.4\text{E+}11\,1/\text{m}^3 = \frac{2.3\text{e}11\,1/\text{m}^3}{1 - 0.022}$$

5) Electron Current Density Formula

Evaluate Formula

Formula

$$J_e = J_T - J_h$$

Example with Units

$$0.03\,\text{A/m}^2 = 0.12\,\text{A/m}^2 - 0.09\,\text{A/m}^2$$

6) Electron Flux Density Formula

Evaluate Formula

Formula

$$\Phi_n = \left(\frac{L_e}{2 \cdot t} \right) \cdot \Delta N$$

Example with Units

$$0.0177\,\text{Wb/m}^2 = \left(\frac{25.47\,\mu\text{m}}{2 \cdot 5.75\,\text{s}} \right) \cdot 8000\,1/\text{m}^3$$

7) Electron Multiplication Formula

Evaluate Formula

Formula

$$M_n = \frac{n_{out}}{n_{in}}$$

Example

$$4 = \frac{60}{15}$$

8) Excess Carrier Concentration Formula

Evaluate Formula

Formula

$$\delta_n = g_{op} \cdot \tau_n$$

Example with Units

$$1E{+}14\,1/m^3 = 2.9e19 \cdot 3.62e{-}6\,s$$

9) Fermi Function Formula

Evaluate Formula

Formula

$$f_E = \frac{n_0}{N_c}$$

Example with Units

$$0.0219 = \frac{1.4e7\,1/m^3}{6.4e8\,1/m^3}$$

10) Hole Current Density Formula

Evaluate Formula

Formula

$$J_h = J_T - J_e$$

Example with Units

$$0.09\,A/m^2 = 0.12\,A/m^2 - 0.03\,A/m^2$$

11) Intrinsic Carrier Concentration Formula

Evaluate Formula

Formula

$$n_i = \sqrt{N_v \cdot N_c} \cdot \exp\left(-\frac{E_g}{2 \cdot [BoltZ] \cdot T}\right)$$

Example with Units

$$2.7E{+}8\,1/m^3 = \sqrt{2.4e11\,1/m^3 \cdot 6.4e8\,1/m^3} \cdot \exp\left(-\frac{0.198\,eV}{2 \cdot 1.4E{-}23\,J/K \cdot 300\,K}\right)$$

12) Mean Time Spend by Hole Formula

Evaluate Formula

Formula

$$\delta_p = g_{op} \cdot \tau_p$$

Example with Units

$$8120\,s = 2.9e19 \cdot 2.8e{-}16$$

13) Photoelectron Energy Formula

Evaluate Formula

Formula

$$E_{photo} = [hP] \cdot f$$

Example with Units

$$757.4472\,eV = 6.6E{-}34 \cdot 183.15\,PHz$$

14) Quantum State Formula

Evaluate Formula

Formula

$$E_n = \frac{n^2 \cdot \pi^2 \cdot [hP]^2}{2 \cdot M \cdot L^2}$$

Example with Units

$$8.2E\text{-}24\,\text{eV} = \frac{2^2 \cdot 3.1416^2 \cdot 6.6E\text{-}34^2}{2 \cdot 1.34e\text{-}5\,\text{kg} \cdot 7e\text{-}10^2}$$

15) Radius of Nth Orbit of Electron Formula

Evaluate Formula

Formula

$$r_n = \frac{[Coulomb] \cdot n^2 \cdot [hP]^2}{M \cdot [Charge\text{-}e]^2}$$

Example with Units

$$4.6E\text{-}8\,\mu\text{m} = \frac{9E{+}9 \cdot 2^2 \cdot 6.6E\text{-}34^2}{1.34e\text{-}5\,\text{kg} \cdot 1.6E\text{-}19\,\text{C}^2}$$

Variables used in list of Semiconductor Carriers Formulas above

- C_L Impurity Concentration in Liquid *(1 per Centimeter)*
- C_{solid} Impurity Concentration in Solid *(1 per Centimeter)*
- E_c Conduction Band Energy *(Electron-Volt)*
- E_g Energy Gap *(Electron-Volt)*
- E_n Energy in Quantum State *(Electron-Volt)*
- E_{photo} Photoelectron Energy *(Electron-Volt)*
- E_v Valence Band Energy *(Electron-Volt)*
- **f** Frequency of Incident Light *(Petahertz)*
- f_E Fermi Function
- g_{op} Optical Generation Rate
- J_e Electron Current Density *(Ampere per Square Meter)*
- J_h Hole Current Density *(Ampere per Square Meter)*
- J_T Total Carrier Current Density *(Ampere per Square Meter)*
- k_d Distribution Coefficient
- **L** Potential Well Length
- L_e Mean Free Path Electron *(Micrometer)*
- **M** Mass of Particle *(Kilogram)*
- M_n Electron Multiplication
- **n** Quantum Number
- n_0 Electron Concentration in Conduction Band *(1 per Cubic Meter)*
- N_c Effective Density of State in Conduction Band *(1 per Cubic Meter)*
- n_i Intrinsic Carrier Concentration *(1 per Cubic Meter)*
- n_{in} Number of Electron in Region
- n_{out} Number of Electron Out of Region

Constants, Functions, Measurements used in list of Semiconductor Carriers Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- constant(s): **[BoltZ]**, 1.38064852E-23 *Boltzmann constant*
- constant(s): **[Charge-e]**, 1.60217662E-19 *Charge of electron*
- constant(s): **[Coulomb]**, 8.9875E+9 *Coulomb constant*
- constant(s): **[hP]**, 6.626070040E-34 *Planck constant*
- Functions: **exp**, exp(Number) *n an exponential function, the value of the function changes by a constant factor for every unit change in the independent variable.*
- Functions: **sqrt**, sqrt(Number) *A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.*
- Measurement: **Length** in Micrometer (µm) *Length Unit Conversion*
- Measurement: **Weight** in Kilogram (kg) *Weight Unit Conversion*
- Measurement: **Time** in Second (s) *Time Unit Conversion*
- Measurement: **Temperature** in Kelvin (K) *Temperature Unit Conversion*
- Measurement: **Energy** in Electron-Volt (eV) *Energy Unit Conversion*
- Measurement: **Frequency** in Petahertz (PHz) *Frequency Unit Conversion*
- Measurement: **Magnetic Flux Density** in Weber per Square Meter (Wb/m²) *Magnetic Flux Density Unit Conversion*
- Measurement: **Volumetric Flow Rate** in Cubic Meter per Second (m³/s) *Volumetric Flow Rate Unit Conversion*
- Measurement: **Surface Current Density** in Ampere per Square Meter (A/m²)

- N_v Effective Density of State in Valence Band *(1 per Cubic Meter)*
- p_0 Holes Concentration in Valance Band *(1 per Cubic Meter)*
- r_n Radius of nth Orbit of Electron *(Micrometer)*
- **t** Time *(Second)*
- **T** Temperature *(Kelvin)*
- T_a Carrier Lifetime *(Second)*
- α_r Proportionality for Recombination *(Cubic Meter per Second)*
- δ_n Excess Carrier Concentration *(1 per Cubic Meter)*
- δ_p Mean Time Spend by Hole *(Second)*
- **ΔN** Difference in Electron Concentration *(1 per Cubic Meter)*
- τ_n Recombination Lifetime *(Second)*
- τ_p Majority Carrier Decay
- Φ_n Electron Flux Density *(Weber per Square Meter)*

Surface Current Density Unit Conversion

- Measurement: **Carrier Concentration** in 1 per Cubic Meter ($1/m^3$)
  Carrier Concentration Unit Conversion
- Measurement: **Reciprocal Length** in 1 per Centimeter (cm^{-1})
  Reciprocal Length Unit Conversion

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