Lecture 8: Electrons and hole currents, IC Resistors

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Announcements

- The midterm is scheduled for March 10, 6-8 pm, in Sibley Auditorium
- The third homework is due Wednesday 2/11

Context:

In the last lecture, we discussed how atoms come together to form insulators, metals and semiconducors

In this lecture, we will cover:

- Electron and hole densities
- Carrier Drift
- Velocity Saturation
- IC Process Flow
- Resistor Layout
- Diffusion

Thermal Equilibrium

- Balance between generation and recombination determines $n_o = p_o$
- Generation is a function of temperature G(T), but recombination only depends on the number of electrons and holes n(r,t) × p(r,t), *because electrons and holes are rare.*

$$G = G_{th}(T) + \not{G}_{opt}$$

$$R = k(n \cdot p)$$

Electron and Hole densities

- But at thermal equilibrium, generation and recombination must be equal:

$$G = R$$

$$k(n \cdot p) = G_{th}(T)$$

$$n \cdot p = G_{th}(T) / k = n_i^2(T)$$

- This holds true for doped as well as intrinsic silicon, and we know:

$$n_i(T) \cong 10^{10}\,\text{cm}^{-3}\ \text{at}\ 300\,\text{K}$$

Law of Mass Action

- This is called the law of Mass action (the name is borrowed from a similar thermal equilibrium law from chemistry)

$$n \cdot p = G_{th}(T) / k = n_i^2(T)$$

- This wouldn't be of much use, except for the fact that we can vary the number of electrons and holes by adding fixed charges to the crystal—by adding nuclei which have an extra proton, or one fewer that silicon.
- In thermal equilibrium, if we increase the number of electrons, the number of holes goes down, and visa versa