Discussion 2: HW#1 & More Thermal Circuits

• Announcements:
  • HW#1 is due next Wednesday

• Today:
  • Sheet resistance
  • HW#1 questions?
  • Thermal circuit example

Sheet Resistance

\[ R = \frac{L}{\sigma A} = \frac{\rho L}{\sigma} \left( \frac{L}{W} \right) \]

\[ A = W \times L \text{ (Area of material)} \]

\[ \rho \text{ (Resistivity)} \]

\[ \sigma \text{ (Conductivity)} \]

\[ e^{- \frac{Ea}{kT}} \text{ (Carrier density)} \]

\[ n \text{ (Electron density)} \]

\[ \mu \text{ (Mobility)} \]

\[ \frac{\mu_e}{\mu_h} \text{ (Ratio of electron to hole mobility)} \]

\[ \frac{\mu_e}{\mu_h} < 1 \] (Non-ideal conditions)

Problem 2

\[ R_{eb} = \frac{P_s (\frac{L}{W})}{W} \]

Folded-beam Suspension

\[ V_a \]

Electrical

Shuttle

Folding Truss

Can we neglect?

\[ V_h = \frac{I_e}{2} \]

\[ P_e = I^2 R_{eb} \]

\[ \text{Current through each beam:} \]

\[ \frac{I_e}{2} \]

\[ \text{Current through a beam:} \]

\[ \frac{I_e}{2} \]
Sample Thermal Problem

- Thickness: $5\mu\text{m}$
- $L = 120\mu\text{m}$
- $T_1$ and $T_2$ are not shown

Given:
- $\rho = 10\mu\Omega\cdot\text{m}$
- $k = 90\text{ W/(m.K)}$

Electric Domain:
- $R_e = R_s \left( \frac{L}{W} \right) = \left( \frac{10\mu\Omega}{5\mu\Omega} \right) \left( \frac{120\mu\text{m}}{3\mu\text{m}} \right) = 120\Omega$
- $V = V_B = \frac{2}{120} = 17\text{ mA}$

Thermal Domain:

$R_{th,bp} = \frac{1}{3} \frac{L}{100\mu\text{m}}$

$R_{th,bp} = \frac{1}{3} \frac{(120\mu\text{m})}{(90\times3\times5\mu\text{m})}$
Steady-State Problem: (Ignore C's)

\[ P_1 = \frac{P}{(R_1 + R_2)} \]

\[ P'' = P_1 \left( \frac{R_k}{\frac{5}{2} R_k} \right) = \frac{1}{5} P_1 \]

\[ \Delta T = P'' \left( \frac{\frac{3}{2} R_k}{\frac{5}{2} R_k} \right) = \left( \frac{5}{3} P_1 \right) \frac{3}{5} R_k \]

\[ \Delta T \text{ contributed by } P_1 \]