Homework set 2 Spring 2001
EE 397K ADV STDS IN ELECTRICAL ENGR; Unique Number 15170
date: 2/21/01
due: 2/28/01

1. Consider a bar 10 microns long, 5 microns wide, and 1 micron thick, connected at one end to a heat sink. Assume the sides of the bar are thermally insulated (vacuum or air would do a pretty good job). Recall the thermal impedance for a rectangular bar is given by

$$Z_{thermal} = \frac{1}{t \cdot w} \cdot \sqrt{\frac{1}{j \cdot \omega \cdot \kappa \cdot \rho \cdot C}} \cdot \tanh\left(\sqrt{\frac{j \cdot \omega \cdot \rho \cdot C}{\kappa}} \cdot l\right)$$

a) Plot the magnitude of $Z_{thermal}$ as a function of frequency from $\omega = 10^2$ rad/sec to 10^8 rad/sec (use a log-log plot, please) for a bar made of SiO_2 and for a bar made of Al.

A dc heat source is placed at the “input” end of the bar, producing a total input power of 1μW.

b) Assuming the bar is made of SiO_2, what is the temperature rise at the “input” end of the bar?

c) Assuming the bar is made of Al, what is the temperature rise at the “input” end of the bar?

2. Consider a heated hemispherical surface or radius $r_o = 2\mu m$. Recall in such a case the dc temperature rise for input power P is given by:

$$\Delta T = \underbrace{\frac{1}{2\pi \cdot \kappa \cdot r_o}}_{\text{thermal spreading resistance}} P$$

b) Assuming the material is SiO_2, what is the thermal resistance at the surface of the hemisphere?
c) Assuming the material is Al, what is the thermal resistance at the surface of the hemisphere?

3. Consider a beam 10 microns long, 5 microns wide, and 1 micron thick, clamped at one end (in other words, it looks like a diving board). Assume the only force acting on the beam is gravity (1 g), and that the beam is horizontal. Recall the deflection for uniformly distributed force is

$$y(x) = \frac{W}{24 \cdot E \cdot I} \cdot \begin{cases} x^2 \cdot \left(6 \cdot a^2 - 4 \cdot a \cdot x + x^2\right) & x < a \\ a^3 \cdot \left(4 \cdot x - a\right) & x > a \end{cases}$$

a) Assuming the beam is made of SiO_2, find the shape under gravitational loading; what is the maximum tip deflection? Repeat, but assume the length is 100 microns.

b) Assuming the beam is made of Al, find the shape under gravitational loading; what is the maximum tip deflection? Repeat assuming the length is 100 microns.