EE 245 / NEEM 6441: Introduction to MEMS Design
Homework 5

Sensing and Noise

1. You've designed a polysilicon strain gauge with a gauge factor of 30. The strain gauge is on top of an oxide cantilever with no residual strain and is hooked up into a Wheatstone bridge where only one component is active. The cantilever width in the bending direction is 2 μm, the width in the non-bending direction is 5 μm, and the length is 100 μm. The Young's modulus of the oxide cantilever is 70 GPa. The minimum resolvable voltage due to the amplifier after the Wheatstone bridge is 100 nV.

    a. Given this minimum resolvable voltage, find the minimum resolvable strain assuming a 5 V supply voltage on the Wheatstone bridge.

    b. What is the minimum resolvable force?

    c. If the force due to gravity was concentrated at the tip of the cantilever, would this be detectable?

    d. How are these answers different if the material used for the strain gauge is not piezoresistive (i.e. the material resistivity does not depend on the strain)?

2. One of, if not the, most successful commercial MEMS sensors is the accelerometer. While some accelerometers are designed to use piezoresistive effects for sensing, many also use capacitive sensing.

    a. What are some of the trade-offs between capacitive and piezoresistive accelerometers?

    b. What are some sources of parasitic capacitance that can effect a capacitive sensed accelerometer? Is there any benefit to integrating the circuits with the accelerometer on the same die?

    c. Given the accelerometer shown below, what is the sensitivity and noise equivalent acceleration? Assume the accelerometer is designed for a bandwidth of 100 Hz.

$N_f = 50$
$g_o = 1\ \mu m$
$w = 100\ \mu m$
$t = 20\ \mu m$
$V_{sup} = 5\ V$
$v_n = 10\ \mu V$

d. What kind of accelerations would you undergo if you were to crash your car into a wall? This is just for fun, so use approximate numbers.