

Micromachined acoustic actuator for the hearing impaired

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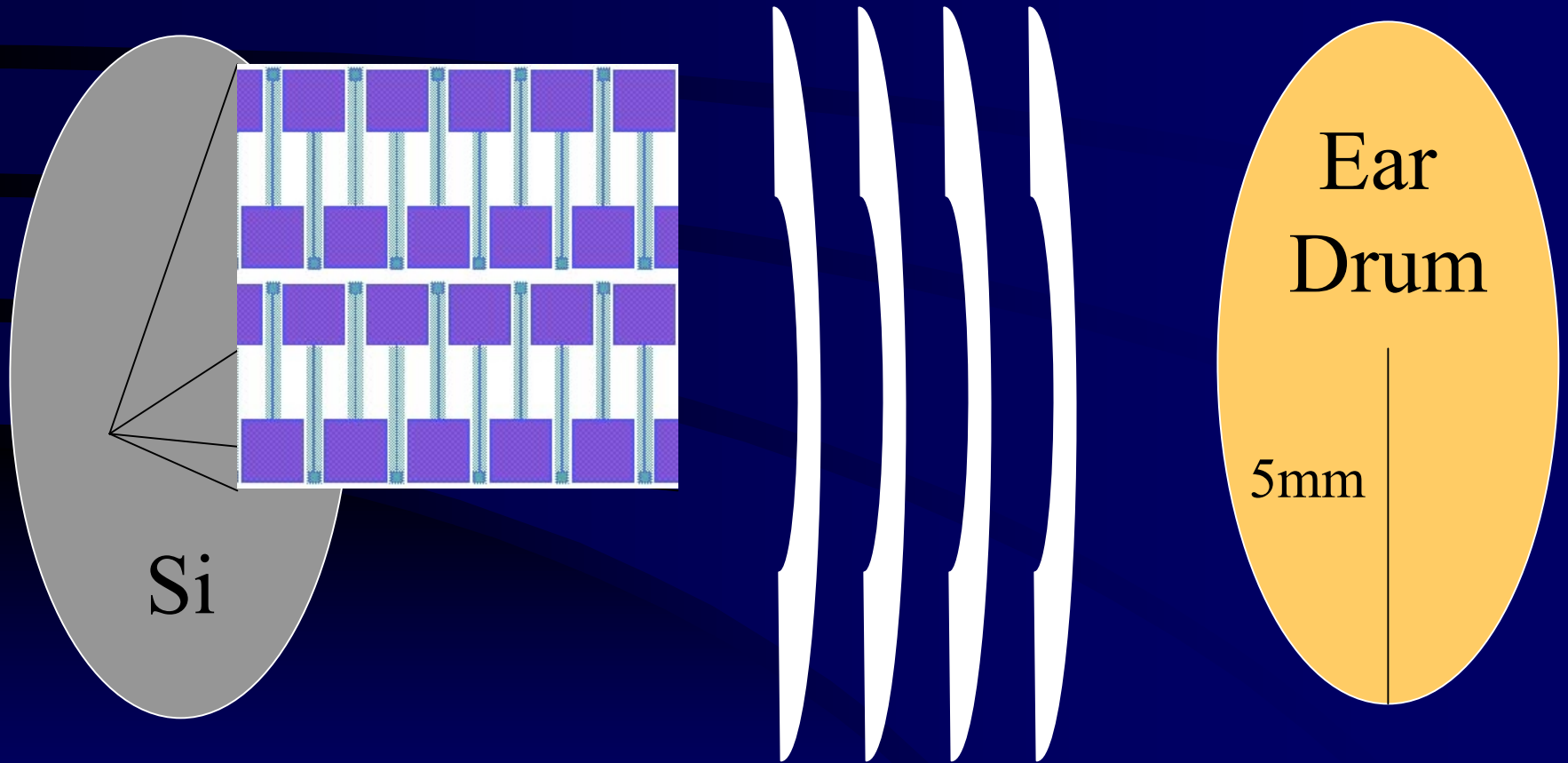
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EE 250B

Introduction

- We designed a micromechanical electrostatic actuator for incorporation into a hearing aid device

Basic Design of Operation



Market Research

- Out of the 260 million people living in the United States, 28 million are hearing impaired.
- 80 percent of hearing-impaired adults who presently are not using amplification to take some action regarding their hearing.
- In 2002, Predicted 7 million units sold = \$2 billion
- Reasons for shunning the aids include personal vanity, the stigma associated with the devices, their cost and the fact that hearing aids are imperfect devices

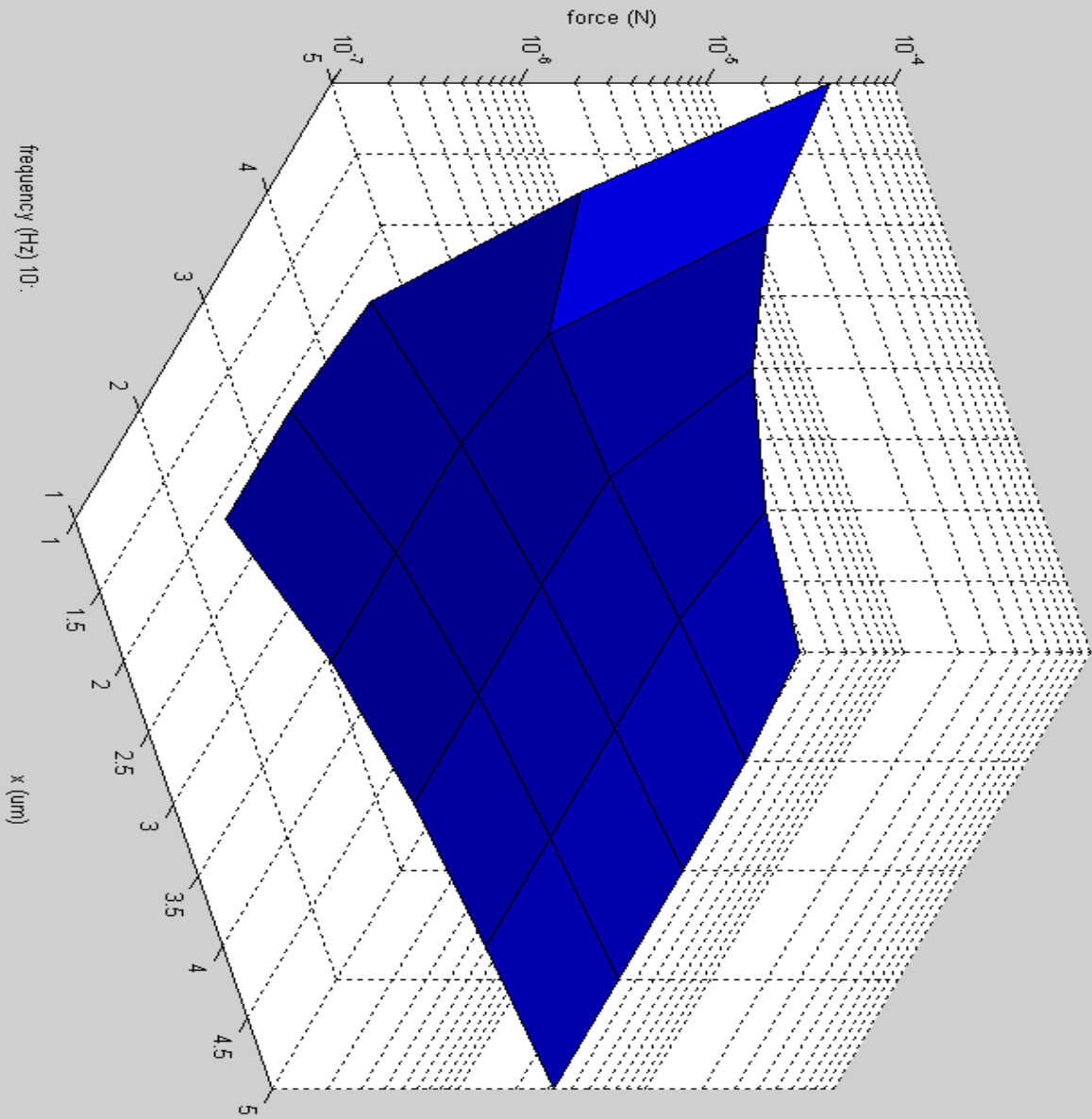
SCREAMING MEMS!

Requirements

- Threshold of hearing: $P_0 = 2e-5 \text{ N/m}^2$
- Desired maximum amplification: $\sim 100 \text{ dB}$
- Range of Hearing: $20 \text{ Hz} - 5 \text{ kHz}$

$$\text{dB} = 20 \log \frac{P_s}{P_0}$$

- $P_s = 1 \text{ N/m}^2$
- $A_d = 8e-5 \text{ m}^2$, $x_d = 150e-9 \text{ m}$
- $W_d/n = W_p \rightarrow F_d x_d/n = F_p x$
- $F_p = (P_s * A_d * x_d)/(n * x)$
- $F_t(s) = F_0(s) + F_p(s)$
- $F_t(\mathbf{f}, \mathbf{x}) = \mathbf{kx} + \mathbf{bsx} + \mathbf{ms}^2\mathbf{x} + (P_s * A_d * x_d)/(n * x)$



Actuation mechanism

- Use electrostatic actuation: parallel plate capacitor model
- Total capacitance is result of 2 dielectric layers: 2 capacitors in series.

$$\left(\frac{1}{C_{air}} + \frac{1}{C_{nit}}\right) = \frac{1}{C_{total}}$$

- Voltage required to pull beam toward substrate is

$$V = \sqrt{\frac{2 Fg}{C_{total}}}$$

Actuation Requirements

Frequency	Voltage (3 μ m gap)	Voltage (2 μ m gap)
1Hz	23.167	15.559
10Hz	23.167	15.559
100Hz	25.739	17.287
1kHz	62.714	42.12
10kHz	197.343	132.54

Fabrication

Nickel



Conclusion

- Using micromechanical electrostatic actuation is not feasible for incorporation into the hearing aid device
- We learned the difficulties of designing a MEMS system.