


EE C245 - ME C218 Introduction to MEMS Design Spring 2014

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Lecture Module 2: Benefits of Scaling


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Lecture Outline

- Reading: Senturia, Chapter 1
- Lecture Topics:
 - ↳ Benefits of Miniaturization
 - ↳ Examples
 - GHz micromechanical resonators
 - Chip-scale atomic clock
 - Micro gas chromatograph

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 **Benefits of Size Reduction: MEMS**

- Benefits of size reduction clear for IC's in elect. domain
↳ size reduction ⇒ speed, low power, complexity, economy
- MEMS: enables a similar concept, but ...
MEMS extends the benefits of size reduction beyond the electrical domain



Performance enhancements for application domains beyond those satisfied by electronics in the same general categories

- Speed → Frequency ↑ , Thermal Time Const. ↓
- Power Consumption → Actuation Energy ↓ , Heating Power ↓
- Complexity → Integration Density ↑ , Functionality ↑
- Economy → Batch Fab. Pot. ↑ (esp. for packaging)
- Robustness → g-Force Resilience ↑

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 **Vibrating RF MEMS**

Vibrating RF MEMS

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Basic Concept: Scaling Guitar Strings

Guitar String

Vib. Amplitude

Low Q

High Q

110 Hz

Freq.

Vibrating "A" String (110 Hz)

Freq. Equation:

$$f_o = \frac{1}{2\pi} \sqrt{\frac{k_r}{m_r}}$$

Stiffness

Mass

Guitar

μMechanical Resonator

Metallized Electrode

W_r

L_r

Anchor

Polysilicon Clamped-Clamped Beam

h_r

[Bannon 1996]

Transmission [dB]

$f_o = 8.5\text{MHz}$

$Q_{vac} = 8,000$

$Q_{air} \sim 50$

Performance:

$L_r = 40.8\mu\text{m}$

$m_r \sim 10^{-13}\text{ kg}$

$W_r = 8\mu\text{m}, h_r = 2\mu\text{m}$

$d = 1000\text{\AA}, V_P = 5\text{V}$

Press. = 70mTorr

Frequency [MHz]

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