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EE C247B – ME C218
Introduction to MEMS Design
Spring 2019

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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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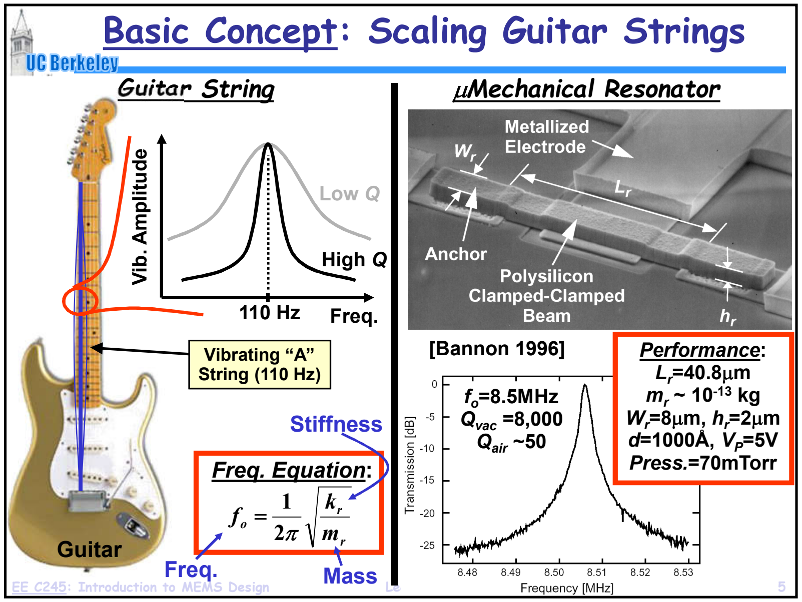
Vibrating RF MEMS


Basic Concept: Scaling Guitar Strings
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Guitar String
μMechanical Resonator
Vib. Amplitude
Low Q
High Q
110 Hz
Freq.
Vibrating "A" String (110 Hz)
Guitar
Stiffness
Freq. Equation:
$f_o = \frac{1}{2\pi}\sqrt{\frac{k_r}{m_r}}$
Freq.
Mass
Metallized Electrode
W_r
L_r
Anchor
Polysilicon Clamped-Clamped Beam
h_r
[Bannon 1996]
f_o=8.5MHz
Q_{vac} =8,000
Q_{air} ~50
Transmission [dB]
Frequency [MHz]
Performance:
L_r=40.8μm
m_r ~ 10^{-13} kg
W_r=8μm, h_r=2μm
d=1000Å, V_P=5V
Press.=70mTorr
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