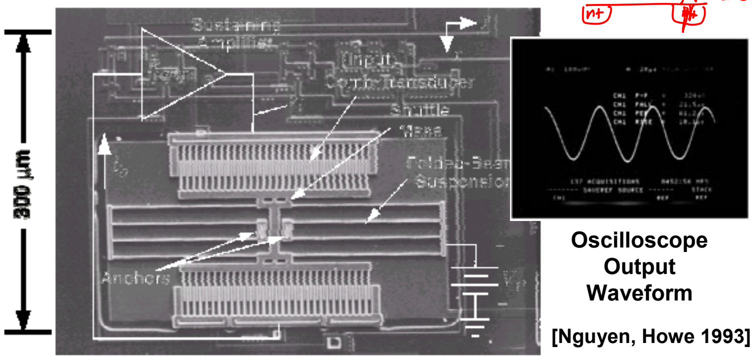
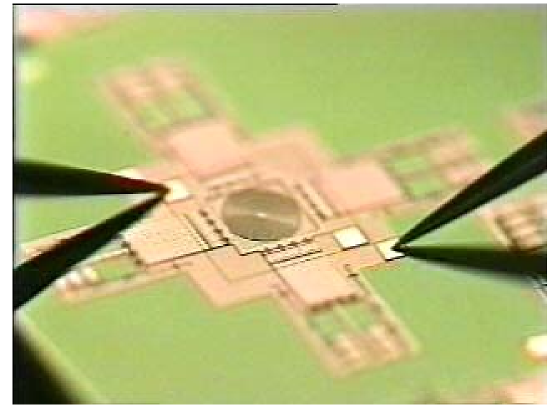
Single-Chip Ckt/MEMS Integration

- Completely monolithic, low phase noise, high-Q oscillator (effectively, an integrated crystal oscillator)



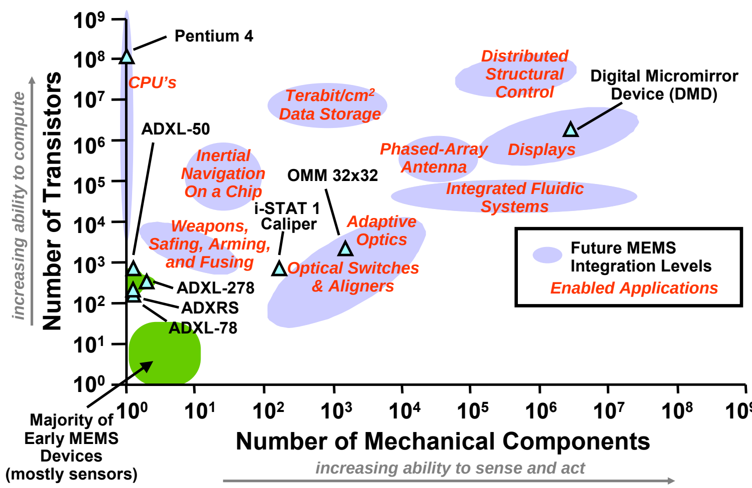
- To allow the use of >600°C processing temperatures, tungsten (instead of aluminum) is used for metallization

3D Direct-Assembled Tunable L



[Ming Wu, UCLA]

Technology Trend and Roadmap for MEMS

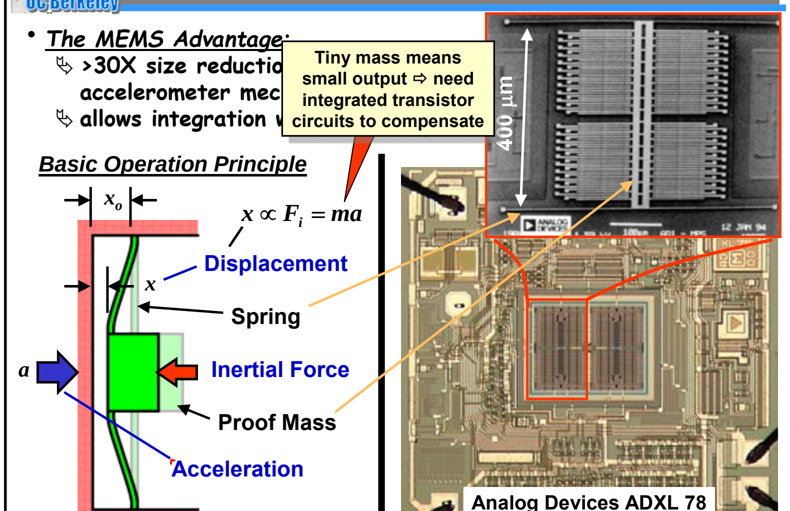


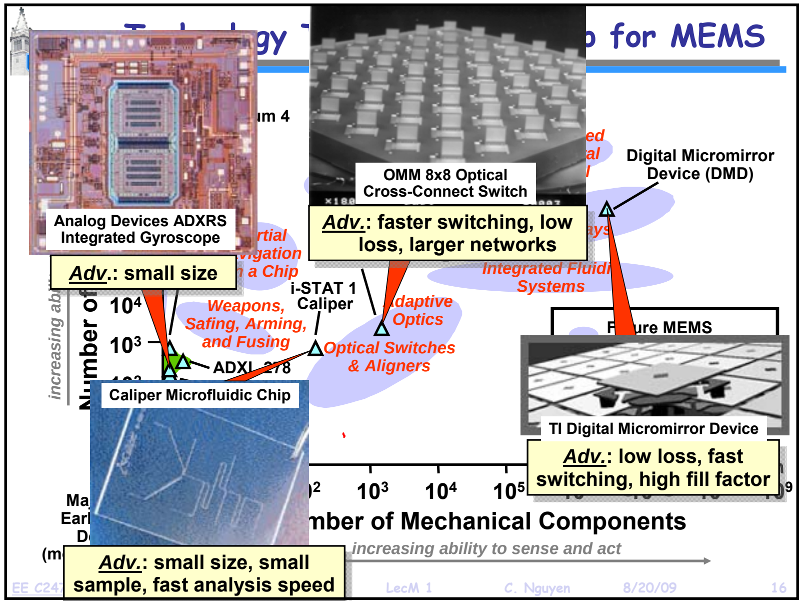
Example: Micromechanical Accelerometer

- *The MEMS Advantage:*
  - >30X size reductio[n] accelerometer mec[hanics]
  - allows integration [w]

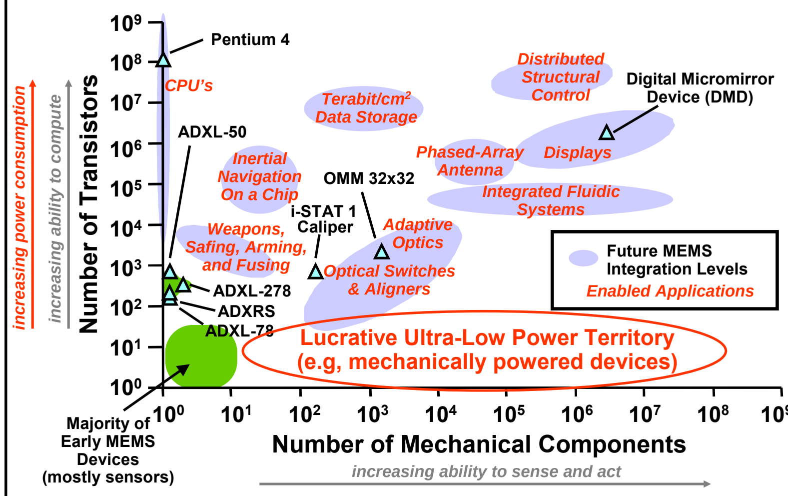
Tiny mass means small output ⇨ need integrated transistor circuits to compensate

Basic Operation Principle





Technology Trend and Roadmap for MEMS



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 …

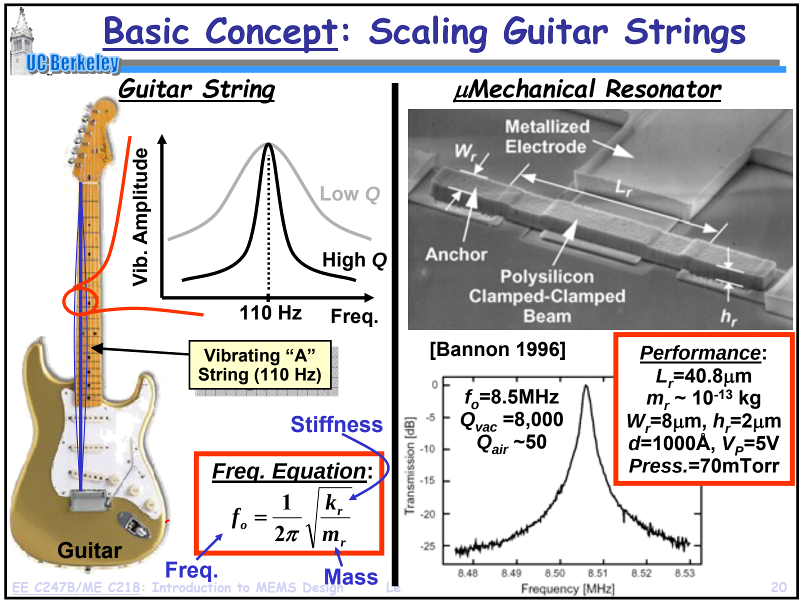
MEMS extends the benefits of size reduction *beyond* the electrical domain

⇩

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 ↑

Vibrating RF MEMS


Basic Concept: Scaling Guitar Strings
UC Berkeley
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
Performance:
L_r=40.8μm
m_r ~ 10^{-13} kg
W_r=8μm, h_r=2μm
d=1000Å, V_P=5V
Press.=70mTorr
Transmission [dB]
Frequency [MHz]
EE C247B/ME C218: Introduction to MEMS Design
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