Lecture Outline

- Reading: Senturia, Chapter 1
- Lecture Topics:
  - Definitions for MEMS
  - MEMS roadmap
  - Benefits of Miniaturization

MEMS: Micro Electro Mechanical System

- A device constructed using micromachining (MEMS) tech.
- A micro-scale or smaller device/system that operates mainly via a mechanical or electromechanical means
- At least some of the signals flowing through a MEMS device are best described in terms of mechanical variables, e.g., displacement, velocity, acceleration, temperature, flow

Input:
voltage, current
acceleration, velocity
light, heat, ...

Output:
voltage, current
acceleration, velocity
light, heat, ...

Control:
voltage, current
acceleration
velocity
light, heat, ...

Transducer to Convert Control to a Mechanical Variable (e.g., displacement, velocity, stress, heat, ...)

Angle set by mechanical means to control the path of light

Other Common Attributes of MEMS

- Feature sizes measured in microns or less
  - Example: deep etching and wafer bonding
- Merges computation with sensing and actuation to change the way we perceive and control the physical world
- Planar lithographic technology often used for fabrication
can use fab equipment identical to those needed for IC's
however, some fabrication steps transcend those of conventional IC processing

Bulk Micromachining and Bonding

- Use the wafer itself as the structural material
- Adv: very large aspect ratios, thick structures
- Example: deep etching and wafer bonding
Surface Micromachining

- Fabrication steps compatible with planar IC processing

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

- Increasing ability to compute
- Increasing ability to sense and act
- Future MEMS Integration Levels Enabled Applications
- Major of Early MEMS Devices (mostly sensors)
- Number of Mechanical Components

Copyright © 2020 Regents of the University of California
Example: Micromechanical Accelerometer

Basic Operation Principle

\[ x \propto F = ma \]

- Tiny mass means small output \( \Rightarrow \) need integrated transistor circuits to compensate

**The MEMS Advantage**
- More than 30x size reduction
- Accelerometer means
- Allows integration

**EE C247B/ME C218**

Number of Transistors (mostly sensors)

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

**Benefits of Size Reduction: MEMS**

- Benefits of size reduction clear for ICs in elect. domain
- Size reduction \( \Rightarrow \) speed, low power, complexity, economy
- MEMS enables a similar concept, but...

**Technology Trend and Roadmap for MEMS**

- Future MEMS
- Faster switching, low loss, larger networks
- Low loss, fast switching, high fill factor

**Number of Mechanical Components**

- Increasing ability to sense and act

**Number of Mechanical Components**

- Enabled Applications

- Lucrative Ultra-Low Power Territory (e.g., mechanically powered devices)

**EE C247B/ME C218: Introduction to MEMS**

Lecture 2m1: Admin & Overview

CTN 1/28/20