Very Quick Start™ MEMS & Microsystems Course

Dr. Ted Dellin

Quick Start Micro Training LLC
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SAMPLE SLIDES FROM COURSE

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Outline of Class

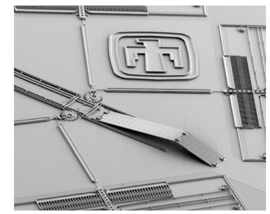
Introduction
(1. Introduction)

Leveraging Silicon Processing
(2. Leveraging the IC Industry; 3. Unit Processes

MEMS Technologies
(4. Bulk MEMS; 5. Surface MEMS; 6. Packaging)

Microsystems
(7. Microsystems; 8. Microsystems Examples)

MEMS:
Micro Electro-Mechanical System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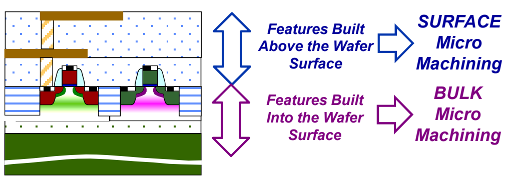
Microscopic structures formed to perform useful mechanical, optical, sensing and other functions.

Often integrated with microelectronics.

IC Manufacturing Capabilities Enable Surface and Bulk Micromachining

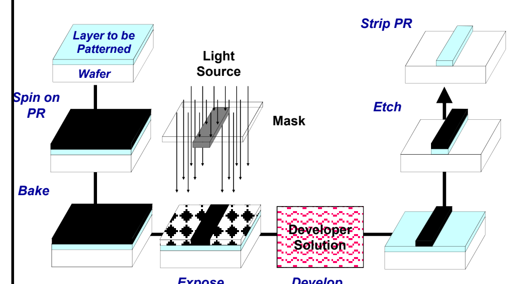


There Are Some Major Differences Between ICs and MEMs

IC ⟺ MEMS

- **Features in a MEMS devices are much bigger than on a state-of-the-art IC**
  - *Minimum size in MEMS >= 1 micron*
- **MEMS films can be much thicker**
  - *E.g., 2 microns*
  - *Greater concern for stresses built into films*
- **MEMS may pattern features on both sides of the wafer**
- **MEMS features may be movable, open to the environment, …**

Pattern Definition Using Positive Photoresist (PR)



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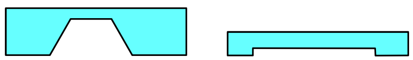
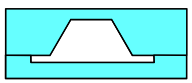
Bulk Micromachining: Etching and Wafer Bonding

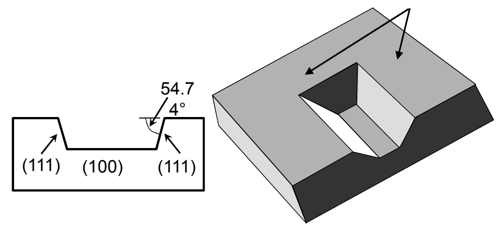
Etching Features Into a Si Wafer ("Subtractive Process")



(optional) Bond Wafers Together

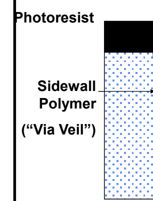


Anisotropic Wet Etching Using KOH Exposes Certain Planes of the Si Crystal



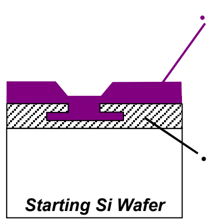
The etching always occurs along precise angles

Etching High Aspect Ratio Features Using Sidewall Polymer Formation



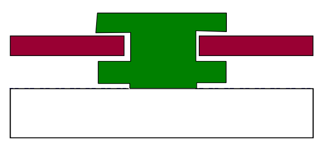
- The chemistry of the etchant is adjusted such that a polymer will form on the sidewalls
- Ion flux removes polymer at bottom of via, but not along sidewalls
- Polymer prevents sidewall etching leading to highly anisotropic etching
- Sidewall polymer must be removed after etch
- Etch rate ~ 10 µm/minute

Desirable Characteristics for Mechanical and Sacrificial Layer



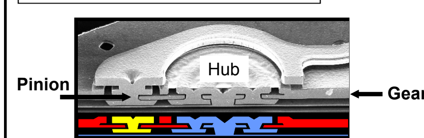
- Mechanical layer
  - *Good mechanical properties*
  - *Good electrical properties*
  - *Good optical properties*
  - *Controllable stress*
- Sacrificial Layer
  - Stable during processing
  - Highly selective etch to remove sacrificial layer without attacking mechanical layer
  - No "stiction" during etch

Fabricating a Gear and Flanged Hub



-Mechanical device is completely formed

-Selectively etch away the sacrifical oxide layers ("release")



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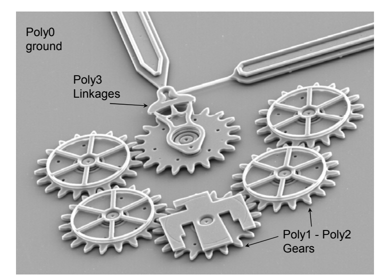
Summit™ Multi Level MEMS Technology



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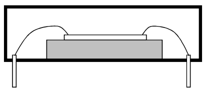
What Makes MEMS/Microsystems Assembly and Packaging Different?

Basically, want everything that IC packaging wants



Plus, one or more of these features

- Let light in and out
- Let fluids and/or gasses in and out
- *Allow for mechanical motion of parts inside package*

Plus, one or more of these complications during assembly

- Need to release surface micromachined parts
- Stiction from liquids or contact
- Temperature requirements
- Susceptibility to particles
- Non-IC materials

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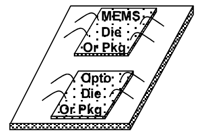
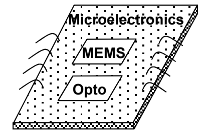
Two Approaches to Microsystems: *Hybrid and Monolithic Integration*

HYBRID Integration
(PC Board, MCM, System-in-a-Package)



Different Technologies Individually Fabricated And Then Assembled Together

MONOLITHIC Integration
(System-on-a-Chip)



Different Technologies Built On a Single Semiconductor Die

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IMEMS: Integrated MEMS + CMOS: *3 Possible Process Variations*

1. MEMS First (not in production)

MEMS ⇨ CMOS

- Wafer stress produced by MEMs can make CMOS processing difficult

2. MEMS In The Middle (e.g., Analog Devices)

Transistors ⇨ MEMS ⇨ Interconnect

- Allows high temperature MEMS processing (e.g., polysilicon)

3. MEMS Last (e.g., Texas Instruments)

CMOS ⇨ MEMS

- Requires low temperature MEMS processing (e.g., aluminum)
- Allows MEMS to be stacked on CMOS

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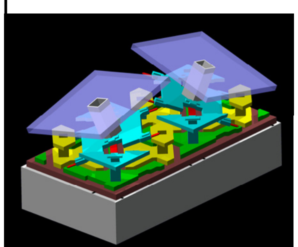
Texas Instruments Digital Light Projector (DLP)™ Device



Courtesy of Texas Instruments

- Each image pixel is controlled by a movable micromirror
  - *Electrostatic actuation*
  - *Mechanical stops, not electrical signal, precisely sets mirror angle*
- In one position light is reflected through a lens and a white dot (pixel) is formed on the screen
- In the other position light is reflected away from the lens resulting in no white dot

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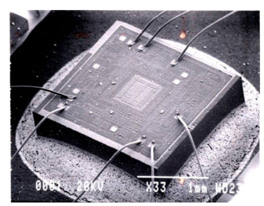
Analog Devices MEMs-Based Accelerometers

- Integrated MEMs accelerometers (center) plus analog circuits for sensing and control
- Different models can sense acceleration in 1-d, 2-d (shown on right) and 3-d
- Initial application: automotive air bag sensors
- Over 200 million produced
- Representative prices: $8-30



Early 1-Axis Accelerometer, Andy Oliver

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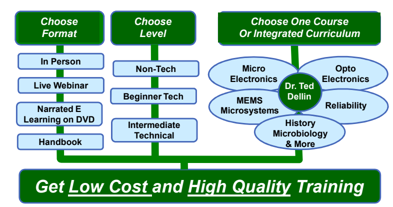

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