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EE C247B - ME C218 Introduction to MEMS Design Spring 2020

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Lecture Module 3: Oxidation & Film Deposition

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Lecture Outline

- Reading: Senturia, Chpt. 3; Jaeger, Chpt. 2, 3, 6
 - ↳ Example MEMS fabrication processes
 - ↳ Oxidation
 - ↳ Film Deposition
 - Evaporation
 - Sputter deposition
 - Chemical vapor deposition (CVD)
 - Plasma enhanced chemical vapor deposition (PECVD)
 - Epitaxy
 - Atomic layer deposition (ALD)
 - Electroplating

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MEMS Fabrication


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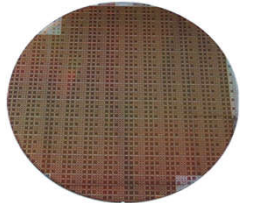
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Making Mechanical Devices

- How best does one make a mechanical product?
- Assembly line production?
 - ↳ Pick and place parts
 - ↳ Used for many macroscopic mechanical products
 - ↳ Robotic automation greatly reduces cost
- **Problem:** difficult to do this with MEMS-scale parts (but not impossible, as we'll soon see ...)
- **Solution:** borrow from integrated circuit (IC) transistor technology
 - ↳ Use monolithic wafer-level fabrication methods
 - ↳ Harness IC's batch methods, where multiple devices are achieved all at once



Automobile Assembly Line



CMOS Integrated Circuit Wafer

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Polysilicon Surface-Micromachining

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- Uses IC fabrication instrumentation exclusively
- **Variations:** sacrificial layer thickness, fine- vs. large-grained polysilicon, *in situ* vs. POCL₃-doping

Hydrofluoric Acid Release Etchant

Free-Standing Polysilicon Beam

300 kHz Folded-Beam Micromechanical Resonator

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Electroplating: Metal MEMS

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- Use electroplating to obtain metal structures
- When thick: call it "LIGA"
- **Pros:** fast low temp deposition, very conductive
- **Cons:** drift, low mech. Q but may be solvable?

Photoresist

Aluminum

Silicon Substrate

Wafer

Aluminum Release Etchant

Electrode

Suspended Nickel Microstructure

Nickel

Ti/Au

Si₃N₄ Isolation

Silicon Substrate

RF Switch

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Bulk Micromachining and Bonding

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

Micromechanical Vibrating Ring Gyroscope

1 mm

[Najafi, Michigan]

Movable Structure

Silicon Substrate

Electrode

Glass Substrate

Metal Interconnect

Anchor

Microrotor (for a microengine)

[Pisano, UC Berkeley]

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