EE 527 MICROFABRICATION

Lecture 2

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INTRODUCTION

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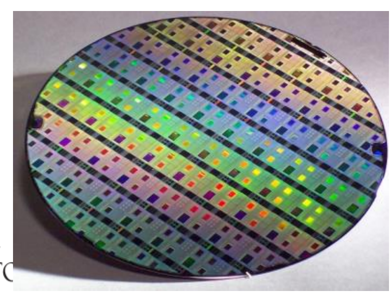
- Integrated circuits, microsensors, microfluidics, solar cells, flat-panel displays and optoelectronics rely on microfabrication technologies.
- Microfabrication: typical dimensions are from 0.02 to 100 µm on the surface of wafers, and from atomic layer thickness (0.1 nm) to hundreds of micrometers vertically.
- Microelectronics makes use of the semiconductor properties of silicon and silicon dioxide.
- Micromechanics makes use of the mechanical properties of silicon.
  – MEMS, BioMEMS, powerMEMS, RF MEMS.
- Optoelectronics devices can be used as light detectors, solar cells, and light-emitting diodes.
- Micro-optics makes use of silicon, silicon dioxide, and silicon nitride as waveguilds and mirrors.

SUBSTRATES

- Silicon is the workhorse of microfabrication.
  – Resistivity can be tailored over a wide range: from 0.001 to 20,000 ohm-cm.
  – Silicon wafers are available in sizes and thicknesses.
  – It is smooth, flat, mechanically strong and fairly cheap.
- Bulk silicon wafers are single crystal pieces cut from larger single crystal ingots and polished.



http://www.xbitlabs.com/images/news/2011-03/silicon_wafer.jpg

WHY USE SILICON?

- take advantage of extensive experience from IC production
- readily available in very pure form (“nine nines”)
- material properties are very well known
- exceptional properties:

  very strong

    yield strength 7×10^9 N/m^2 vs. steel 4.2×10^9 N/m^2

  relatively light

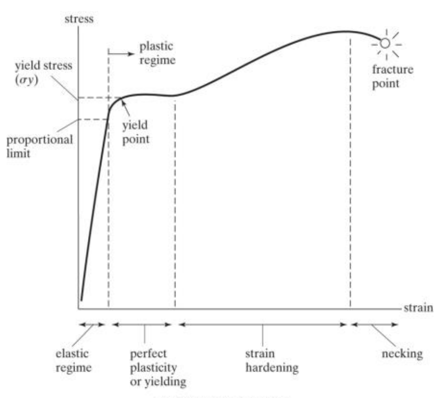
    density 2.3 g/cm^3 vs. steel 7.9 g/cm^3

  semiconductor

    resistivity .5mΩ-cm (doped) to 230 kΩ-cm

TENSILE STRESS AND STRAIN

A tensile test is commonly used to determine the stress-strain relation.



- Strong: high yield strength or ultimate strength.

PROCESSES

- Microfabrication processes consist of four basic operations:
  - High-temperature processes to modify the substrate.
  - Thin-film deposition on the substrate.
  - Patterning of thin films and substrate (Removal of thin films or substrate).
  - Bonding and layer transfer

PROCESSES

- Arrhenius equation is a general and useful description of the rate of thermally activated processes.

$$\text{rate} = z(T)e^{(-E_a/kT)}$$

Where $k = 1.38 \times 10^{-23}\ \mathrm{J/K} = 8.62 \times 10^{-5}\ \mathrm{eV/K}$

E_a is the activation energy

- Many fabrication processes show Arrhenius-type dependence: etching, resist development, oxidation, epitaxy, chemical vapor deposition, diffusion, and grain growth.