Lecture 10: Mechanics of Materials I

- Announcements:
- Module 6 on Bulk Micromachining online
- Module 7 on Mechanics of Materials online
- HW#2 due this coming Friday morning
- Wednesday Office Hours will change to 12:30-1:30 p.m. starting next week
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- Reading: Senturia Chpt. 3, Jaeger Chpt. 11, Handouts: "Bulk Micromachining of Silicon"
- Lecture Topics:
  - Bulk Micromachining
  - Anisotropic Etching of Silicon
  - Boron-Doped Etch Stop
  - Electrochemical Etch Stop
  - Isotropic Etching of Silicon
  - Deep Reactive Ion Etching (DRIE)
  - Wafer Bonding
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- Reading: Senturia, Chpt. 8
- Lecture Topics:
  - Stress, strain, etc., for isotropic materials
  - Thin films: thermal stress, residual stress, and stress gradients
  - Internal dissipation
  - MEMS material properties and performance metrics
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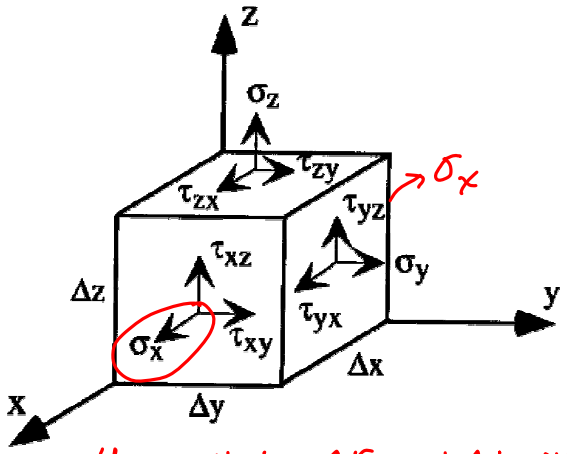
- Last Time: Going thru Module 6 … finish this
- Move on to Module 7

Example. Exercise the "terms"

⇒ Determine the volume change ΔV for a uniaxial stress (along the x-direction)



Upon application of σ_x, what is ΔV?

$\Delta x \rightarrow \Delta x(1+\epsilon_x)$ (as a results of application of σ_x)

$\Delta y \rightarrow \Delta y(1-\nu\epsilon_x)$ } assuming isotropic material → same ⇒ along y & z

$\Delta z \rightarrow \Delta z(1-\nu\epsilon_x)$ }

The resulting change in volume: ΔV

$$\Delta V = \underbrace{\Delta x \Delta y \Delta z (1+\epsilon_x)(1-\nu\epsilon_x)^2}_{\text{volume after application of } \sigma_x} - \Delta x \Delta y \Delta z$$

$= \Delta x \Delta y \Delta z \left[(1+\epsilon_x)(1-\nu\epsilon_x)^2 - 1 \right]$

[Assume small strains] $\Rightarrow (1+mx)^n \approx 1+nmx$

$\Delta V = \Delta x \Delta y \Delta z \left[(1+\epsilon_x)(1-2\nu\epsilon_x) - 1 \right]$

$$\boxed{\Delta V = \Delta x \Delta y \Delta z (1-2\nu)\epsilon_x}$$

For $\nu = 0.5$ (rubber) $\rightarrow$ no ΔV!

$\nu < 0.5 \rightarrow$ finite ΔV