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EE C247B – ME C218
Introduction to MEMS Design
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Lecture Module 7: Mechanics of Materials

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Outline

- 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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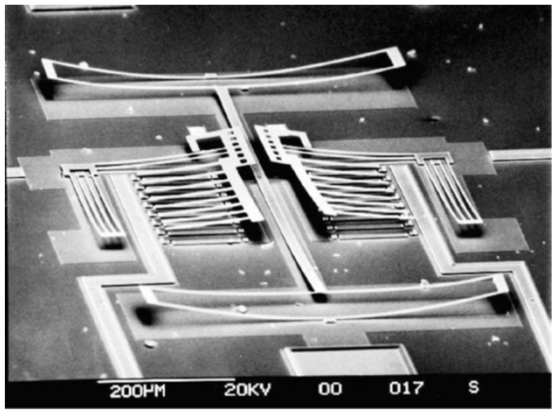
Vertical Stress Gradients

- Variation of residual stress in the direction of film growth
- Can warp released structures in z-direction



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Elasticity

Normal Stress (1D)

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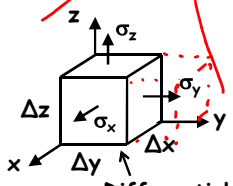
If the force acts normal to a surface, then the stress is called a normal stress

Force assumed uniform over the whole area A

Stress = {Force per unit area} = $\sigma = \frac{F}{A}$ [N/m^2 : Pa]

↑ standard mks unit



Differential volume element

⇒ Microscopic Definition: force per unit area acting on the surface of a differential volume element of a solid body

⇒ Note: assume stress acts uniformly across the entire surface of the element, not at just a point

Strain (1D)

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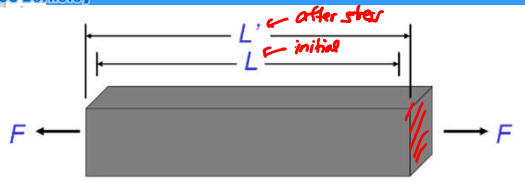
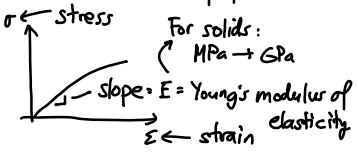


Sometimes a unit called the "microstrain" is used, where

$1\mu\varepsilon = \frac{\Delta L}{L}$ of 1 part in 10^6

Strain = {Fractional Change in Length} = $\varepsilon = \frac{L'-L}{L} = \frac{\Delta L}{L}$ [unitless]

In the elastic regime (i.e., for "small" stresses at "low" temperatures), strain is found to be proportional to stress



$\sigma = \varepsilon E \rightarrow$ $\boxed{\varepsilon = \frac{\sigma}{E}}$ [unitless]

Thus, the units of E are the same as σ → Pa