Lecture 11: Mechanics of Materials II

Announcements:
- HW#3 due Tuesday, 3/10, at 8 a.m.
- Module 8 on “Microstructural Elements” online soon
- 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
- Reading: Senturia, Chpt. 9

Lecture Topics:
- Bending of beams
- Cantilever beam under small deflections
- Combining cantilevers in series and parallel
- Folded suspensions
- Design implications of residual stress and stress gradients

Last Time:
- Going thru Module 7 on “Mechanics of Materials”
- Just finished thermal expansion stress
- Now, continue with Module 7 this …

Springs and suspensions very common in MEMS
- Coils are popular in the macro-world; but not easy to make in the micro-world
- Beams: simpler to fabricate and analyze; become “stronger” on the micro-scale → use beams for MEMS

Problem: Bending a Cantilever Beam

Objective: Find relation between tip deflection \( y(x=L_c) \) and applied load \( F \)

Assumptions:
1. Tip deflection is small compared with beam length
2. Plane sections (normal to beam’s axis) remain plane and normal during bending, i.e., “pure bending”
3. Shear stresses are negligible
Forces & Moments

Moment due to $F_i$ here = $M_1 = F_iL$

Reaction force (to maintain equilibrium)

Equal & opposite to

Moment due to $F_i$ here

$M_2 = F(l-x')$

Total Force: $-F_R + F_{x' i} = -F + F = 0$

Total Moment: $-M_R + M_{x' i} + x'F_{x' i} = -F_L + F(l-x') + x'F = 0$