Measurement of Stress Gradient

- Use cantilever beams
  - Strain gradient ($\Gamma = \text{slope of strain-thickness curve}$) causes beams to deflect up or down
  - Assuming linear strain gradient $\Gamma$, $z = \Gamma L^2/2$

Folded-Flexure Suspensions

- Comb-Driven Folded Beam Actuator

Folded-Beam Suspension

- Use of folded-beam suspension brings many benefits
  - Stress relief: folding truss is free to move in y direction, so beams can expand and contract more readily to relieve stress
  - High y-axis to x-axis stiffness ratio

Beam End Conditions

- Table of commonly used support conditions for beams and frames

[From Reddy, Finite Element Method]
Common Loading & Boundary Conditions

* Displacement equations derived for various beams with concentrated load $F$ or distributed load $f$

\[
x = \frac{F}{k}, \quad y = \frac{F}{k}, \quad z = \frac{F}{k}
\]

(a) Concentrated load.

\[
\begin{array}{c|c|c}
\text{cantilever} & \text{guided-end} & \text{fixed-fixed} \\
\hline
x = \frac{F}{k} & x = \frac{F}{k} & x = \frac{F}{k} \\
y = \frac{F}{k} & y = \frac{F}{k} & y = \frac{F}{k} \\
z = \frac{F}{k} & z = \frac{F}{k} & z = \frac{F}{k}
\end{array}
\]

(b) Distributed load.

Series Combinations of Springs

* For springs in series w/ one load
  - Deflections add
  - Spring constants combine like "resistors in parallel"

\[
Y(L) = F/k = 2 \frac{F}{k_c} = F(1/k_c + 1/k_c)
\]

Compliances effectively add:

\[
1/k = 1/k_c + 1/k_c \quad \Rightarrow \quad k = k_c + k_c
\]

Parallel Combinations of Springs

* For springs in parallel w/ one load
  - Load is shared between the two springs
  - Spring constant is the sum of the individual spring constants

\[
Y(L) = \frac{F}{k} = \frac{F}{k_a} + \frac{F}{k_b} = \frac{F}{2} (1/k_a)
\]

\[
k = 2 k_a
\]