MEMS system partitioning

Hybrid vs monolithic

Integrate the MEMS directly with its electronics — VS — Two seperate chips

e.g.,
- Analog device™ accelerometer
- Motorola™ pressure sensors.

e.g., Sensenor AS™ pressure sensor (SP15)

⇓ Tremendous impact

Design process

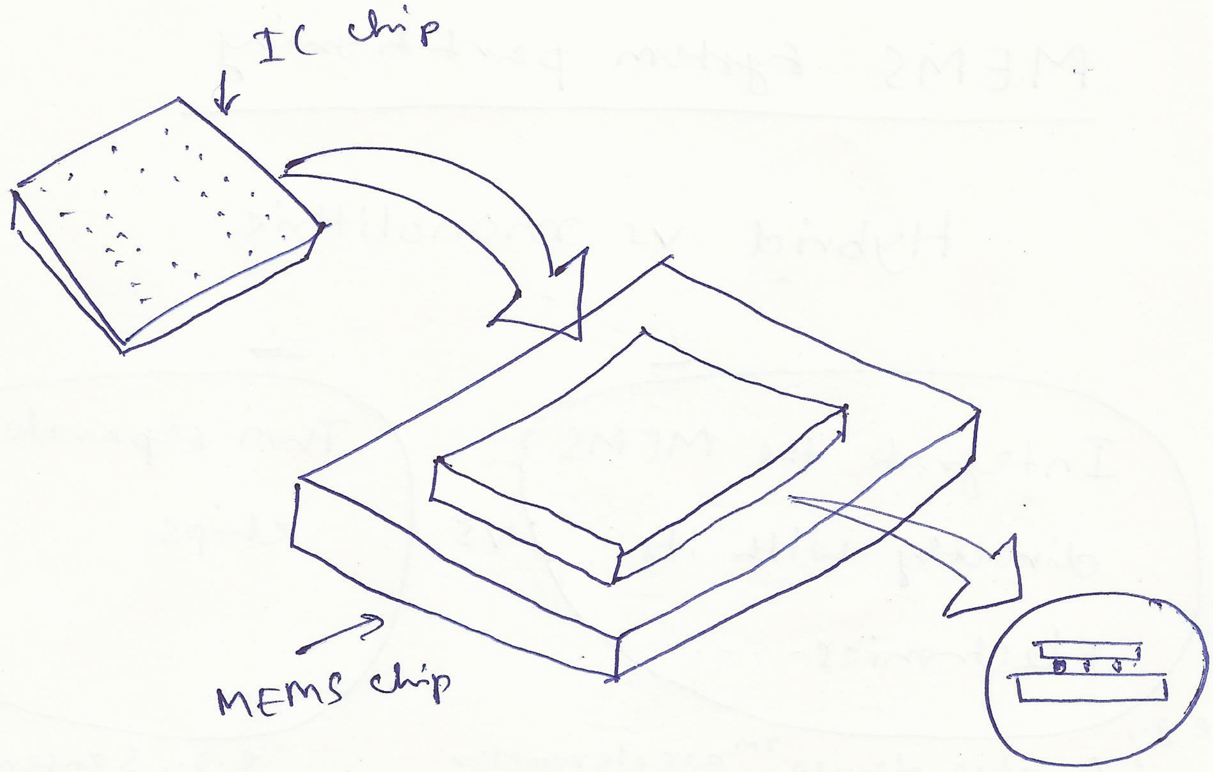
- Limitations due to surface vs bulk micromachining "smaller yield"
- packaging simpler
- Better in compactness & reliability.
- integrated system

- Best of both worlds & "better yield".
- packaging more involved
- compactness & reliability suffers.
- Electronics is away from sensing & wires connecting them introduce additional noise (for small signals) ⟹ AD™ iMEMS. led to compromise

Hybrid: MEMS chip & ASIC are mounted side by side in a metal frame (common) before encapsulation in the same package

↳ system in the package (SIP).

Intermediate solution



Flip-chip assembly

Drawback: Hide MEMS chip surface preventing inspection or, open use.

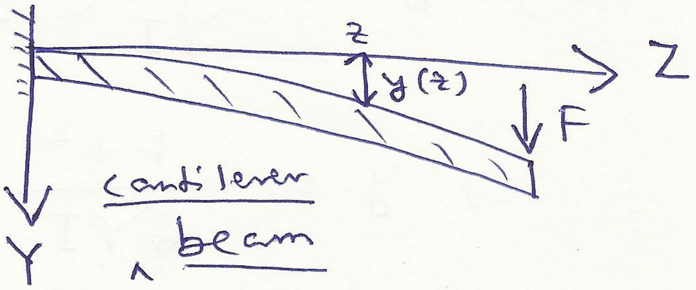
A convenient approach

...to split different subsystems entering the design of MEMS into...

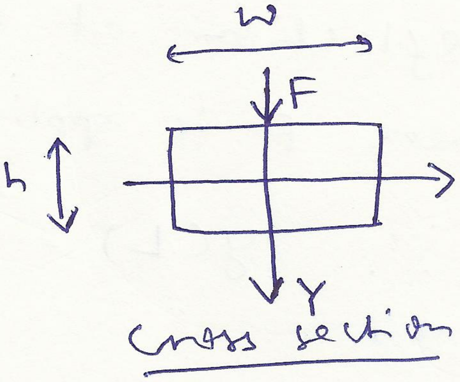
- Active structures: Transducers (Task: Link between environment & the system).
- Passive structures: Support, Guide, Channel (Task: Transport energy within the system).

Ingredients for LEM

- **Springs (cantilever version).**



A beam submitted to a pure internal transverse bending moment M has a deflection y(z) given by:



$$\frac{d^2y}{dz^2} = -\frac{M}{YI}.$$

Y : Young's modulus.

$I : \int_S x^2 dA = \frac{wh^3}{12}$. (2nd M.I. for the beam C.S.).

For the section submitted to a point load normal to the surface at its end, the moment is given by,

$$M(z) = F(L-z).$$

$$\Rightarrow \frac{d^2y}{dz^2} = -\frac{F}{YI}(L-z).$$

Integrating, $y = -\frac{F}{YI}\left(\frac{1}{2}Lz^2 - \frac{z^3}{6} + Az + B\right).$

$$\left.\begin{array}{l} y(z) = 0 \text{ at } z = 0 \\ \& \ \frac{dy}{dz} = 0 \text{ at } z = 0 \end{array}\right\} \Rightarrow A = B = 0.$$

$$\Rightarrow y = -\frac{F}{YI}\left(\frac{L}{2}z^2 - \frac{z^3}{6}\right)$$

$$\Rightarrow y = -\frac{Fz^2}{6YI}(3L - z).$$

Deflection at the end of the beam where F is applied is

$$\therefore \quad y(L) = -\frac{2FL^3}{6YI} = -\frac{FL^3}{3YI}.$$

$\Rightarrow$ Equivalent spring constant

$$k = \frac{F}{y(L)} = \left(\frac{3YI}{L^3}\right) = \frac{Ywh^3}{4L^3}.$$

Type	Deflection	Max. def.	k
Cantilever 	$y = \frac{Fz^2}{6YI}(3L-z)$	$y(L) = \frac{FL^3}{3YI}$	$\frac{3YI}{L^3}$
Clamped-clamped 	$y = \frac{F}{192YI}(12Lz^2 - 16z^3)$	$\frac{FL^3}{192YI}$ $\left(= y\left(\frac{L}{2}\right)\right)$	$\frac{192YI}{L^3}$.

$\equiv$ 4 springs in series (equiv. to cantilevers of lengths $L/4$).