

Lecture 17

RF MEMS (5)

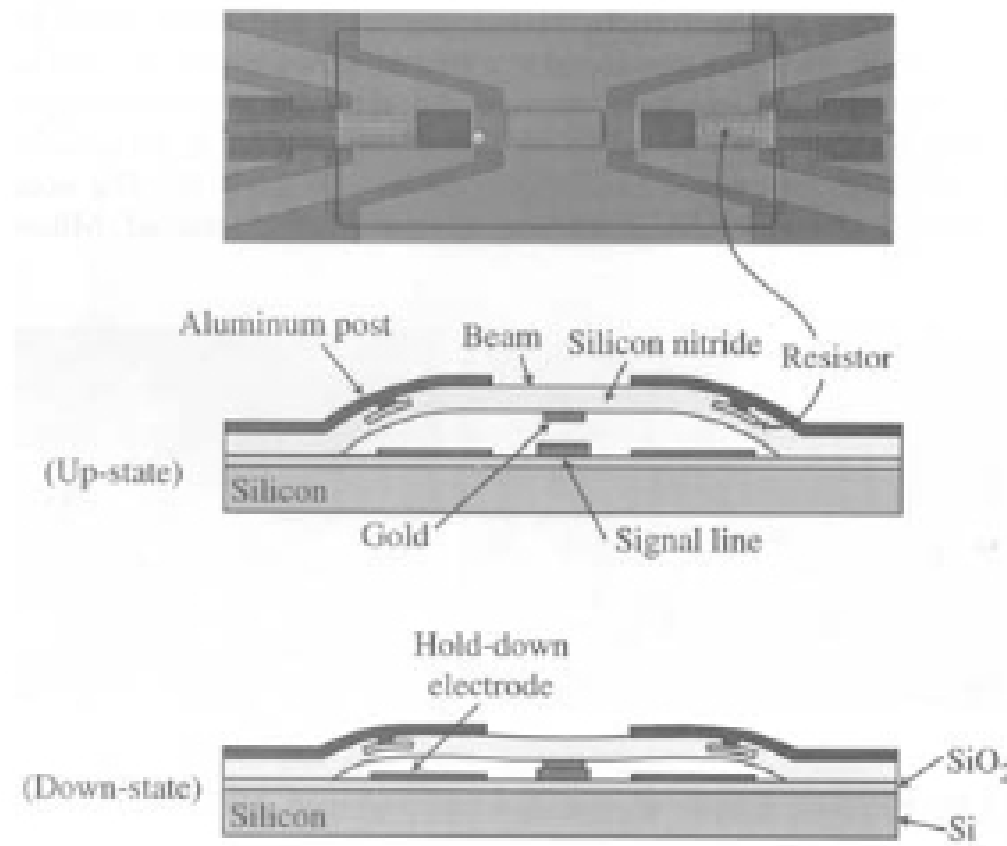
■ Agenda:

- MEMS Switches
 - Non-electrostatic switches
 - Packaging

Most figures and data in this lecture, unless cited otherwise, were taken from RF MEMS Theory, Design and Technology by G. Rebeiz.

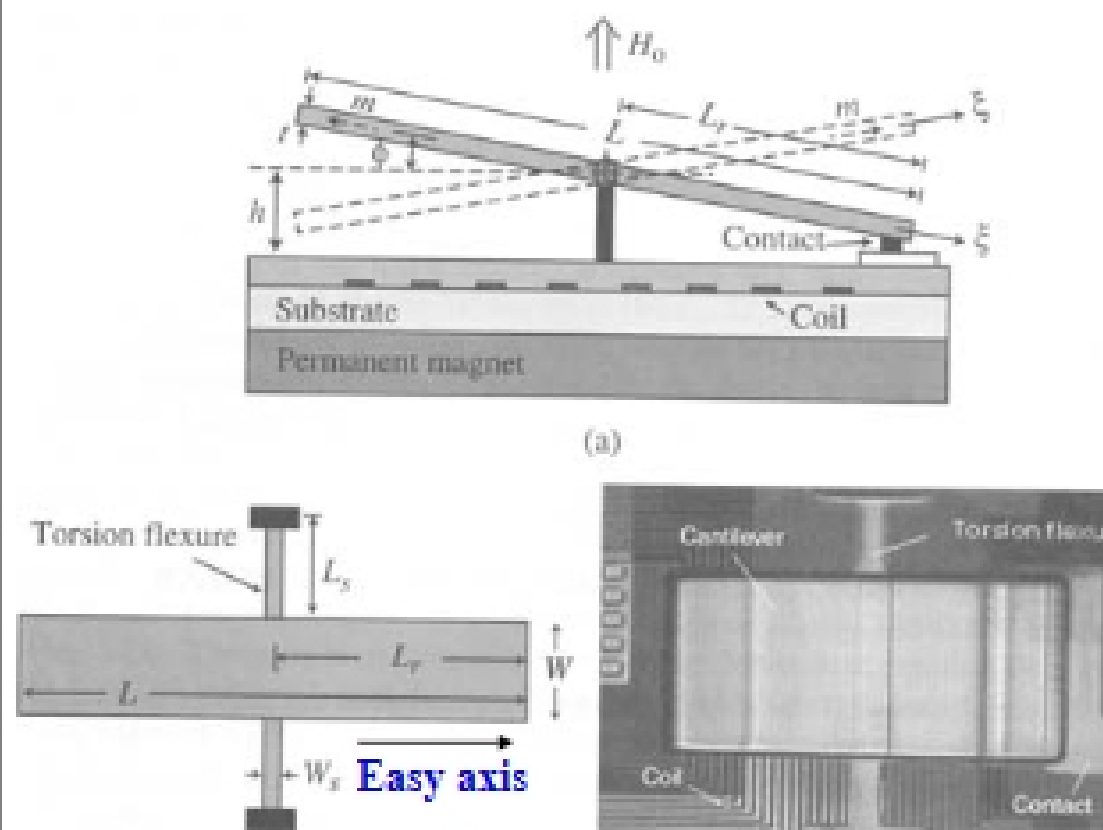
- Thermal-Electrostatic DC-Contact Switch
- Magnetic Latching Series Switch
- Lateral DC-Contact Series Switch
- Piezoelectric Actuation
- Rotary Switch

ST-Microelectronics



- Thermal actuation: Large displacement, low voltage but high power consumption
- Thermal actuation temporarily closes the bridge. Then electrostatic actuation takes over and thermal heating is immediately turned off.
- Electrostatic actuation: Low power
- Membrane consists of compressive and tensile stresses
- Integrated heater (TaN)
- Actuation voltage: 5-25 V
- Switch time: 250-400 μ s

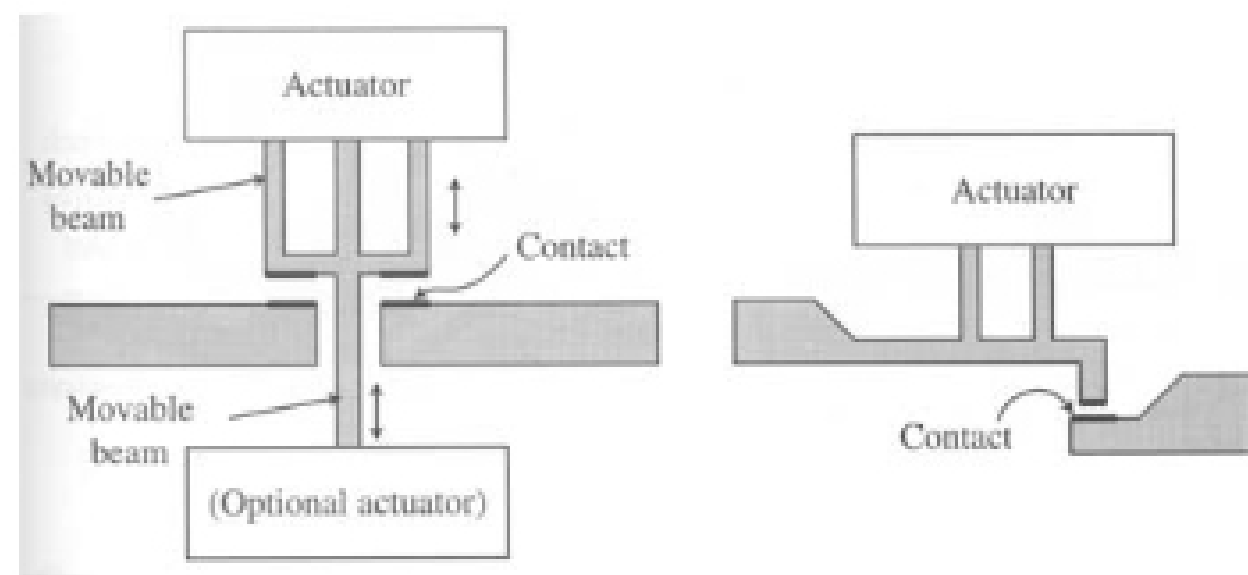
Microlab, Inc.



Ruan et al, MEMS 2001

- Permalloy beam aligns with external permanent H field
- Clockwise or counter-clockwise tilting depends on magnetization of the beam
- A coil (20 turns) is placed under the beam and a current pulse generates a momentary H field to change the magnetization orientation and thus flip the switch
- Only a short current pulse is needed and no hold-down power is need \rightarrow Low Power
- Actuation current/voltage: 80-120 mA/5-6 V
- Switch time: 0.4 ms

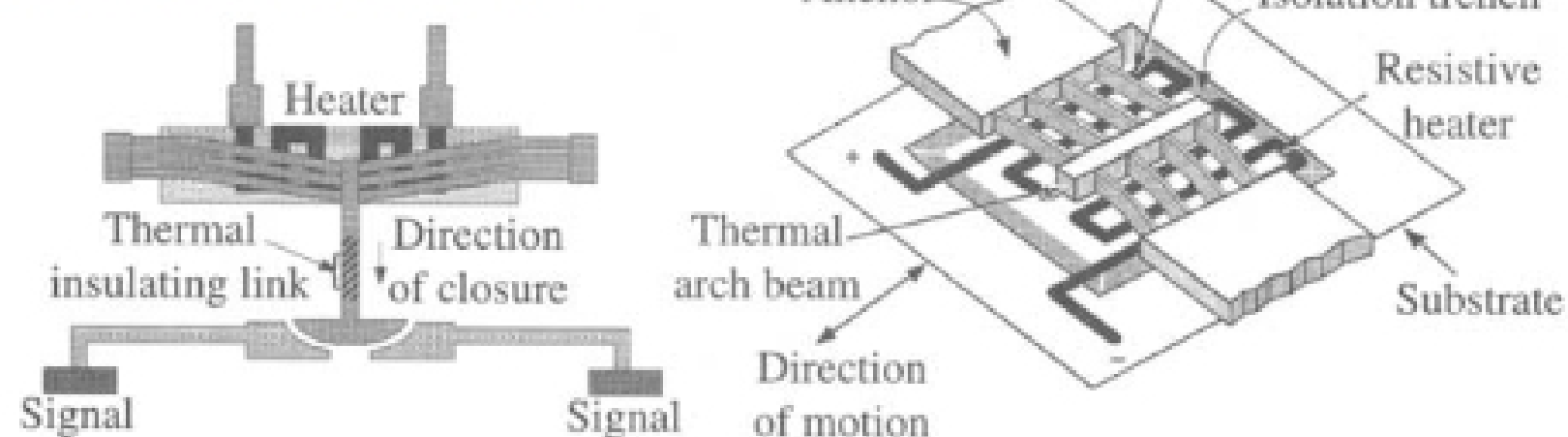
□ Lateral Actuation



- Single-layer structure
- Bi-directional forces
- High aspect-ratio structures for high-current handling (50-500mA)
- Bulk micromachining, thick poly-Si, electroplating
- Roughness of sidewalls
- High-force actuators needed, such as thermal, PZT

□ Cronos (now MEMSCap)

(Wood, Madadevan, Streeter, et al.)



- A thermal arch beam over an integrated resistive heater and a thermal isolation trench
- Thick electroplating nickel (~10 μ m) structures
- 2mN force and 10 μ m displacement for 75K temperature rise
- The switch contact is thermally isolated from the actuator
- Actuation power: 150-250 mW Switch resistance: 0.7 Ω
- Switch time: 6-10 ms Maximum RF current: 350 mA