Electrostatic Micromotor
What is Surface Micromachining?

**Surface Micromachining** is the process of forming movable structures by placing the structures on initially rigid platforms, then removing the platforms, usually by etching the material away.

**Bulk Micromachining** means that 3D features are etched into the bulk of crystalline and non-crystalline materials.
History of Surface Micromachining

1. 1967, resonant gate transistor by Nathanson
2. 1980s, Howe, Muller and Guckel are pioneers
3. 1989, the first survey of possible applications by Gabriel
4. 1991, ADXL-50 by Analog Devices
5. Recently, Texas Instruments, Digital Micromirror Device
Why Surface Micromachining?

Key Benefits of Surface Micromachining:
1. Compatibility with CMOS Processing
2. Single-sided Wafer Processing
3. Small Device Size
4. Cost Effective
Fabrication Steps

1. Sacrificial Layer Deposition and Etching (Also Spacer or Sacrificial Layer)
2. Deposition of Structure Material
3. Selective Etching of Spacer Layer
Micro-Optics
Micro-Gripper
ADI Accelerometer
ADI Accelerometer
Varieties of Surface Micromachining

1. Polysilicon
   (1) LPCVD Polysilicon (2) Hinged Polysilicon
   (3) Milli-Scale Molded Polysilicon Structures

2. SOI
   (1) SFB (Silicon Fusion Bonding) Wafer
   (2) SIMOX (Separated by Implanted Oxygen)
   (3) Selective Epitaxy

3. Resists
   (1) AZ 4000 Series (2) Epon SU8

4. LIGA
TI DMD

1. Clear
2. Better Resolution
3. Bright
4. Lifelike Color
5. Reliable
6. Portable
Programmable Micro Mirror Array
MUMP at MCNC

MUMPs is a three-layer polysilicon surface micromachining process designed to be as general as possible to provide maximum user flexibility. Polysilicon is used as the structural material, deposited oxide (PSG) as the sacrificial material, and silicon nitride for electrical isolation from the substrate. The process is derived from work performed by the Berkeley Sensors and Actuators Center at the University of California, Berkeley.
Linear Comb Resonator
Closeup of Comb Drive Fingers
Rotary Side Drive Motor - Top View
Rotary Side Drive Motor - Side View
Rotary Comb Drive
Resisitive Fuse Link (UC Berkeley)
Micro Relay
Large Pop-up Structure
Closeup Sideview of Hinge
Large Pop-up Structure
PROBLEMS

1. Stiction
   Surface tension or residual contamination
   (1) Stand-off bumps (2) Polymer spacer materials
   (3) Liquid CO2

2. Stress
   (1) Non-uniform plastic deformation
   (2) Thermal expansion (3) growth
   (4) Misfit/impurities (5) Phase transformation

3. IC & MEMS Integration
Polysilicon Beam

Substrate

PSG

Rinse water

Substrate

Substrate