Strategies for dynamic Soft-Landing in Capacitive MicroElectroMechanical Switches
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Multiple Reliability Challenges in RF-MEMS

- Dielectric Charging
  - Charges are injected into the dielectric
  - Causes pull-in/pull-out voltage to change
  - Lead to failure due to stiction

- Creep
  - Causes membrane to move down
  - Capacitance keeps on increasing

- Surface Degradation
  - Caused by impact velocity
  - Energy dissipation at the surface
  - Lead to failure due to stiction

Soft Landing

- Technique to reduce surface degradation by reducing impact velocity
- Traditional techniques
  - Closed loop requires feedback of position or velocity (Not possible for an ensemble of switches)
  - Open loop use input waveform shaping (requires additional circuitry and sensitive to process variation)
- Proposed Techniques
  - Resistive Braking
  - Capacitive Braking

Dynamics of the Switch

- Resistive Braking
  - Remote resistance causes dramatic reduction in the impact velocity
  - Remote resistance below 1MΩ does not change the pull-in time significantly

- Capacitive Braking
  - Patterning of electrode M1/M2 or dielectric reduces the impact velocity
  - Patterning does not change the pull-in voltage and pull-in time significantly
  - For p5 impact velocity decreases with the decreases in fractal dimension Df

Energy Dissipation during Resistive Braking

- Total energy supplied by the voltage source $E_T$
- Surface dissipation $E_d$ decreases at the cost of increased remote resistive dissipation $E_R$
- Total energy dissipated at the dielectric surface $E_d(=1/2mv^2_{impact})$

Capacitive Braking

- Patterning of electrode M1/M2 or dielectric reduces the impact velocity
- Patterning does not change the pull-in voltage and pull-in time significantly
- For p5 impact velocity decreases with the decreases in fractal dimension Df

Conclusion

- Two novel techniques for reducing impact velocity are proposed which do not require any complex external circuitry.
- Resistive braking requires putting a resistance in series with the voltage source.
- Capacitive braking requires patterning of the electrode or the dielectric.