Lecture 18
RF MEMS (6)

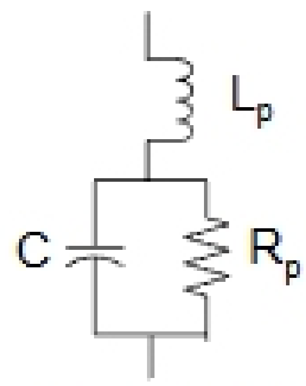
- Agenda:
  - MEMS Varactors: Survey
  - MEMS Inductors: Survey

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

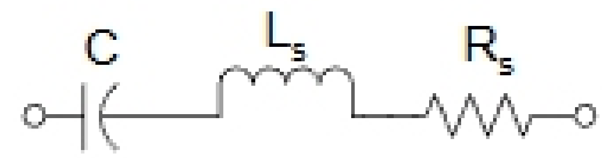
MEMS Varactors

- **Solid-state varactors**
  - Si, GaAs, SiGe
  - Q: 30-60
  - Capacitance ratio 4-6
- **MEMS Varactors**
  - High Q: >100
  - Low cost
  - Small capacitance ratio: 1.2-2.5
  - Small capacitance (not suitable for below 1 GHz)

Varactor Model and Q-Factor



Parallel model



Series model

$$Q = \omega \frac{\text{average energy stored}}{\text{energy loss/second}}$$

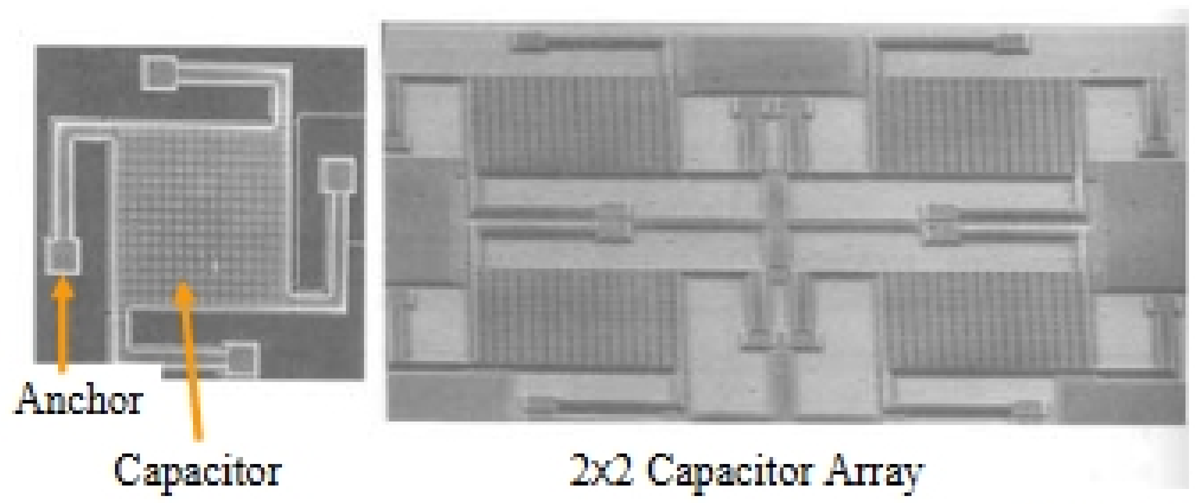
$$Q = \frac{|\text{Im}(Z)|}{\text{Re}(Z)} = \begin{cases} \dfrac{1}{\omega R_s C} & \text{For a series model} \\ \omega R_p C & \text{For a parallel model} \end{cases}$$

MEMS Varactors

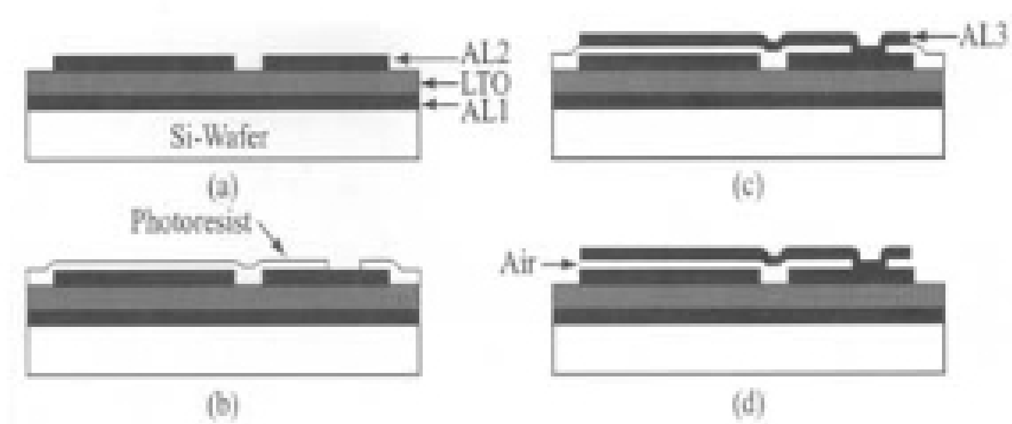
- Electrostatic Parallel-pate Varactors
- Tunable Interdigitated Capacitors
- Thermal Varactors
- Piezoelectric Parallel-pate Varactors
- MEMS Switched Capacitors
- MEMS Varactors with Discrete Values

MEMS Varactors: Electrostatic

❑ Parallel-pate Varactor



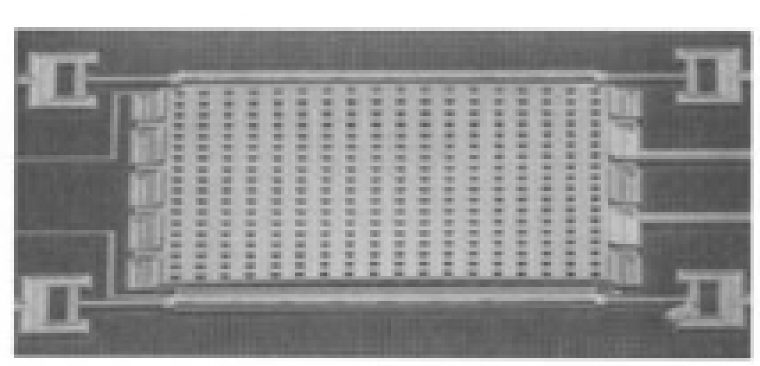
Young and Boser
(UC-Berkeley)
Hilton Head 1996



- Al plates
- 1.5µm gap
- 15% capacitance change at 3V, limited by parasitics
- Q = 60 at 1GHz
- Low-temperature process
- CMOS-compatible

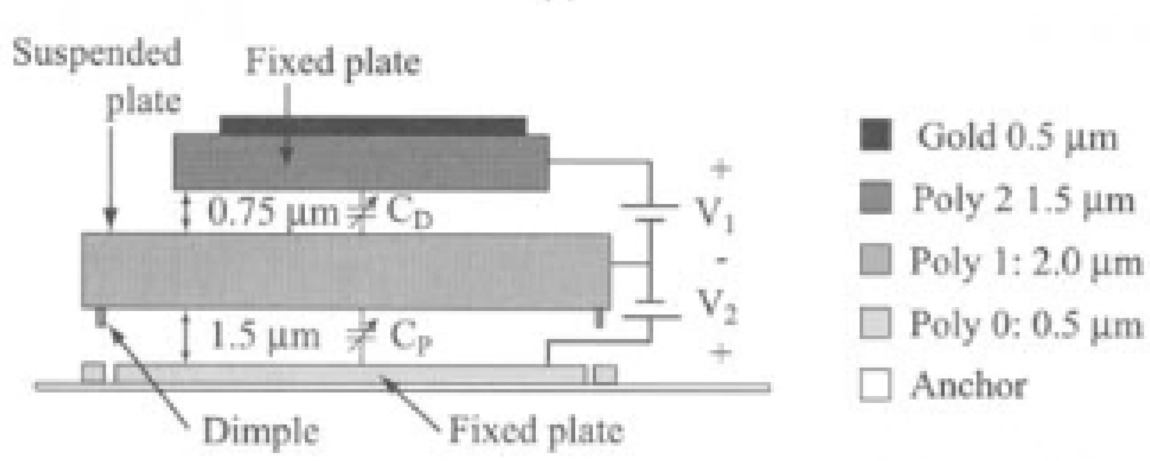
MEMS Varactors: Electrostatic

❑ Three-pate Varactor



(a)

- Fabricated using poly-Si MUMPs
- 0.75/1.5µm gaps
- Tuning range 3.4pF – 6.4pF at 4.5V
- Q = 16 at 1GHz



(b)

Dec and Suyama (Columbia University)
IEEE Trans. MTT, 2000