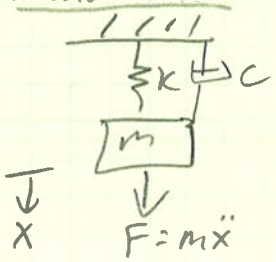
1. Inertial MEMS Devices

→ inertial forces : $m\ddot{x}$ displaces the proof mass against the suspension system restraining force

a. Accelerometer



at steady state: $Kx = m\ddot{x} = ma$

let x = displacement $= d \rightarrow d = a\frac{m}{K} = aS$

S = accelerometer sensitivity

$S = \frac{m}{K} = \frac{1}{\omega_n^2}$, $[S] = s^2$

b. Gyroscope

→ Resonating or vibrating proof mass along x-axis

→ If rotated with angular rate, Ω, about z-axis, sinusoidal motion occures along y-axis due to the Coriolis acceleration: $a_y \approx 2\Omega\dot{x}$

c. Pressure Sensor

→ very similar to an accelerometer except that the proof mass is replaced by a diaphragm or a membrane that deforms due to a difference in Pressure

$P_1 = P_2$ $\quad P_1 > P_2$ $\quad P_2 > P_1$

P = Force/area $= F/A \rightarrow F = PA = Kx$, displacement, $x = \frac{PA}{K}$

→ For more indepth coverage: take ELEC 5760/6760: Solid State Sensors

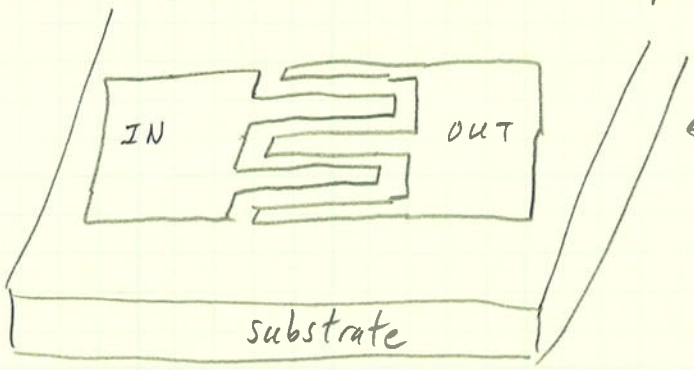
2. RF MEMS

→ MEMS Technology can enable unique RF Devices

a. Static RF MEMS Device

① RF Capacitors

i. Interdigital Capacitor : C ≤ 1pF typically

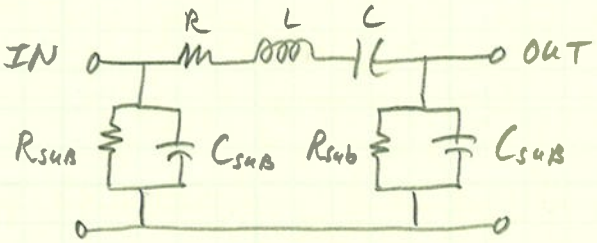


← "non" MEMS cap

Electrodes → plated metal

on non-conductive substrate

RF model :



R_{SUB}, C_{SUB} → parasitics due to the substrate → limits the properties of the RF capacitor

MEMS Technology

→ Remove the substrate from up under the interdigitated electrode fingers

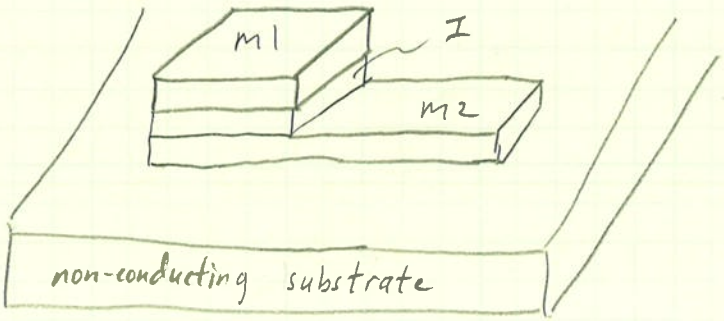
possible techniques → (1) anisotropic wet etch

(2) XeF_2 dry etch

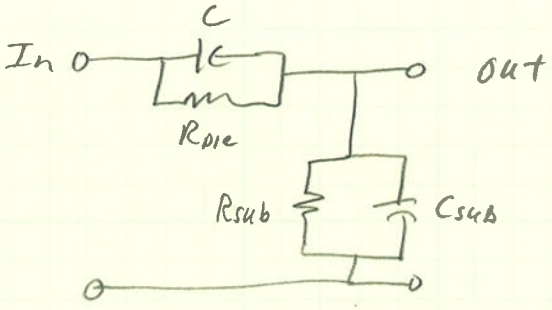
(3) backside DRIE

→ 2:1 performance improvement is possible

b. MIM Capacitor : C > 1pF typically
↳ "metal - insulator - metal"



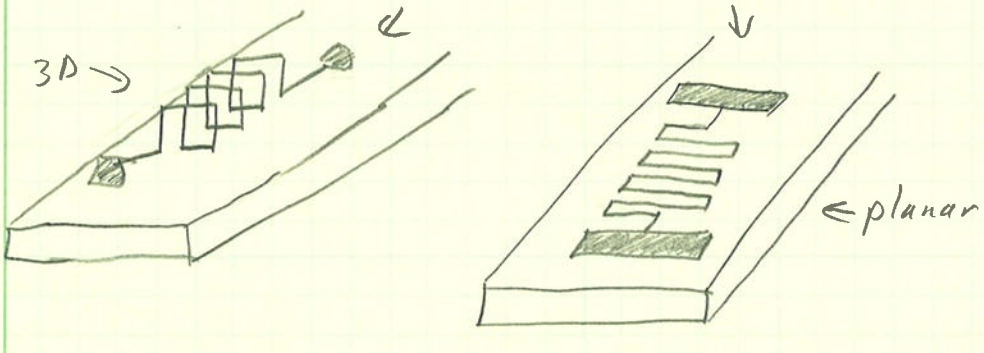
RF model :



→ also improve by removing substrate under the cap area

② RF Inductors

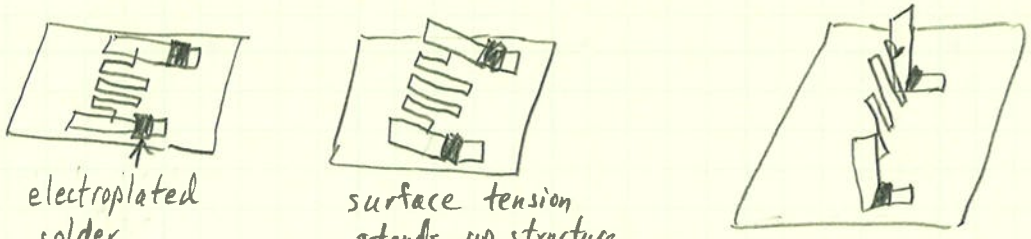
→ Electroplated Coil and Planar Inductors on non-conductive substrates



→ Improve by removing substrate from under inductor structure

* Self Assembled Inductor

(1) Planar Fab (2) heat solder (3) cool solder



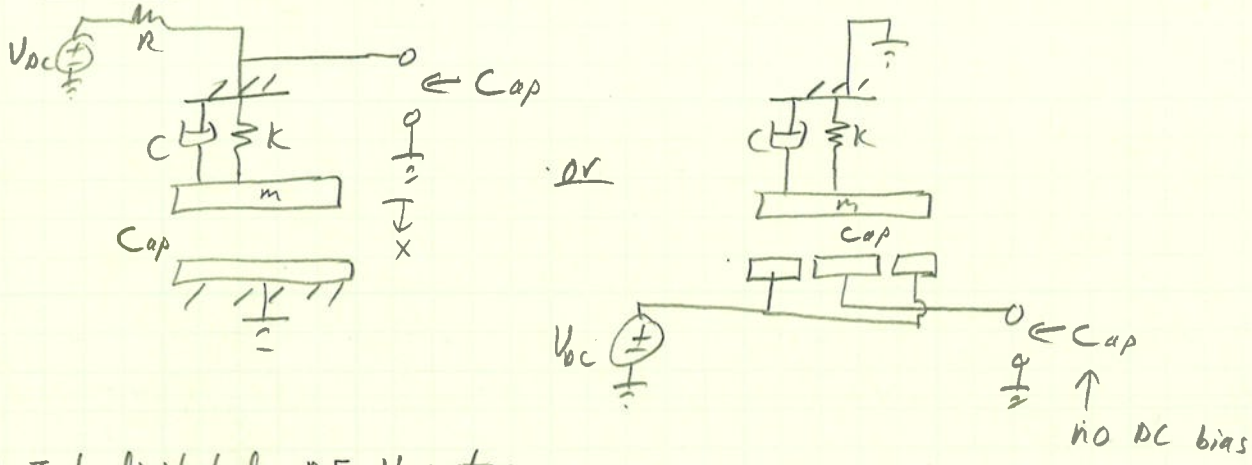
b. Variable RF Devices → Varactors

→ tunable RF caps : usually consists of a high DC voltage variable capacitor used in low voltage RF applications

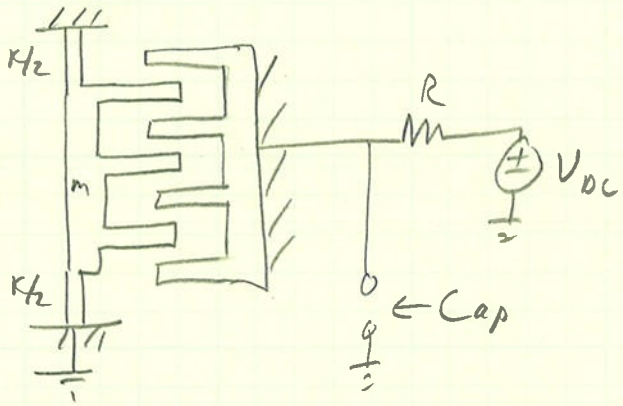
→ DC adjustment voltage does not affect RF circuit

i.e. → use DC blocking caps, etc.

① Parallel Plate RF varactor



② Interdigitated RF Varactor



c. Other Types of RF MEMS Devices

① antennas : planar, 3D, tunable

② switches : contact, low/high capacitance → open or snapped in PPA

③ RF cavity resonators

④ micromachined high freq mechanical resonators

⑤ micromachined acoustic wave devices : SAW, etc.

⑥ MEMS combined with RFID technology : sensors, etc.