Source/Drain Diffusion Resistor

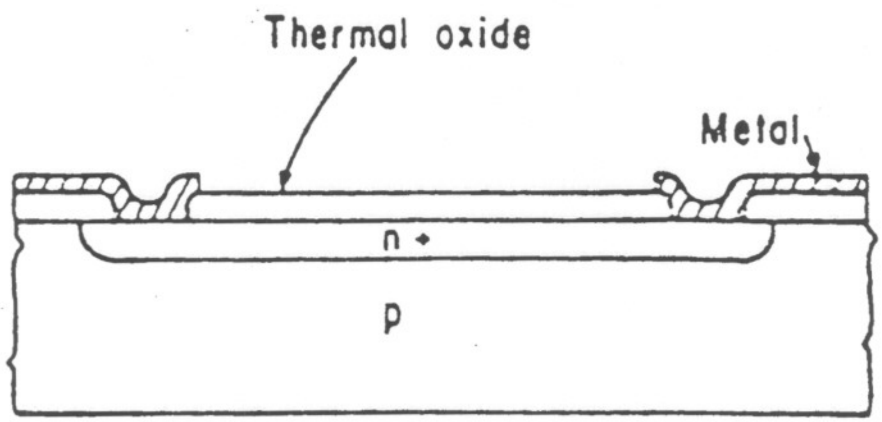


Fig: Resistor formed in source-drain diffusion.

$$R_{\square} = 20 - 80\Omega/\square$$

$$TCR = 500 - 1500ppm/°C$$

$$Tolerance = \pm 15\%$$

Polysilicon Resistor

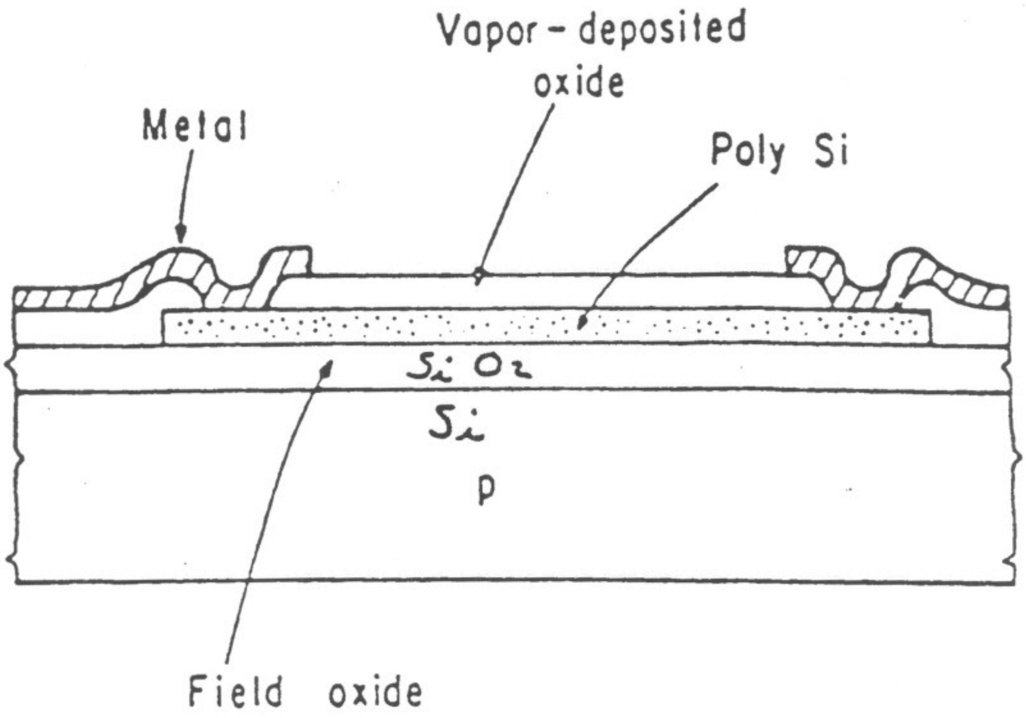


Fig: Resistor formed in polysilicon.

$R_\square \approx 20 - 80\Omega/\square$

$TCR \approx 500 - 1500 ppm/°C$

Tolerance $= \pm 10\%$

Usually denser than diffused resistor.

Well Resistor
(CMOS)

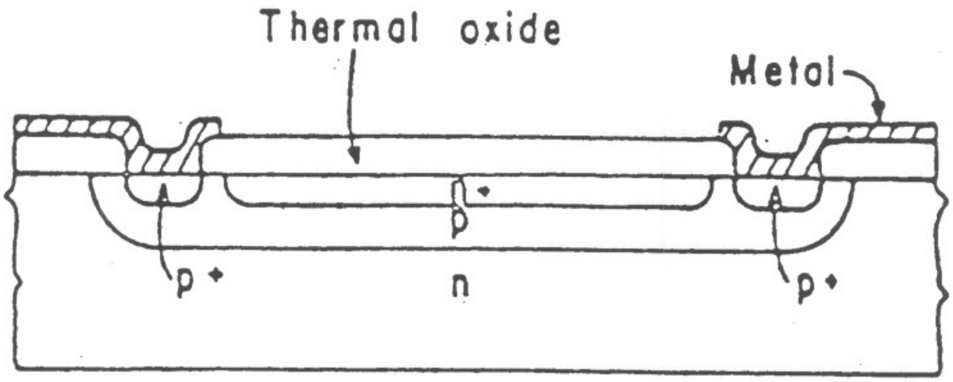


Fig: "Pinched" resistor in a CMOS well.

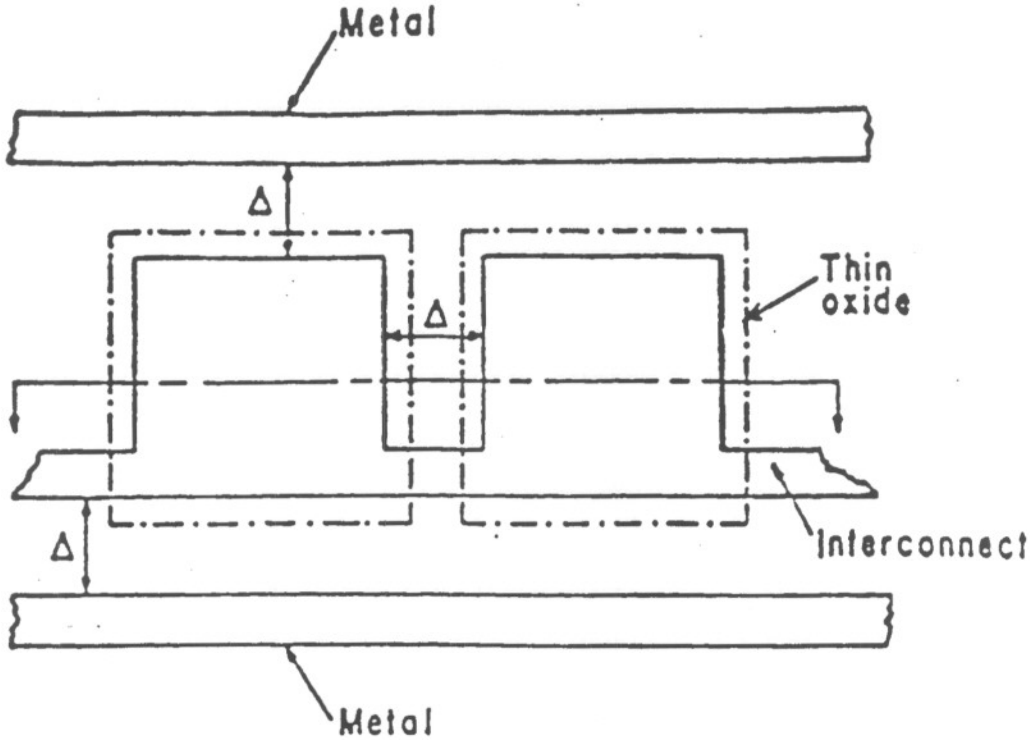
$R_\square \approx$ 1k - 5kΩ/□

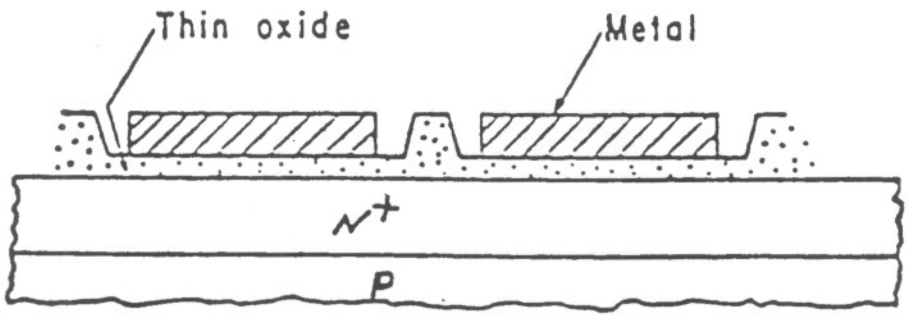
TCR ≈ 4000ppm/°C

Tolerance ≈ ± 20%

Large VCR

Capacitors: Metal-Diffusion





C	=	$3.7 fF/\mu^2$ @ 100 Å
TCC	≈	25ppm/°C
Tolerance	≈	± 10%
VCC	≈	25ppm/V

Poly to Silicon

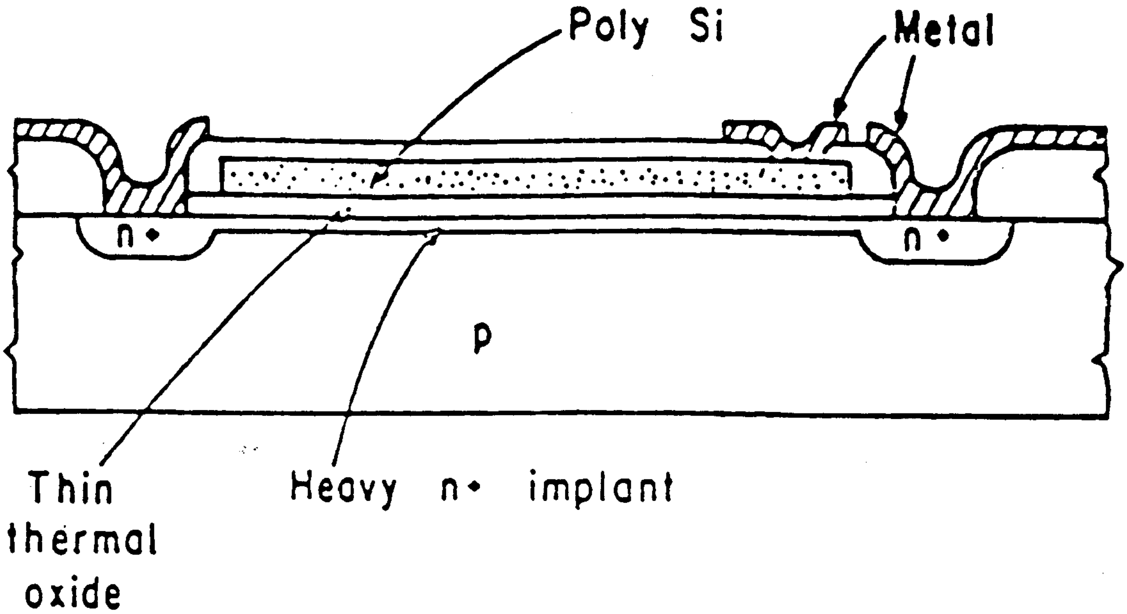


Fig: Capacitor with polysilicon as top plate and heavily implanted bottom plate.

Requires extra mask

Useful for single poly

Properties like metal-diffusion if bottom plate is heavily doped

Poly-Poly Capacitor

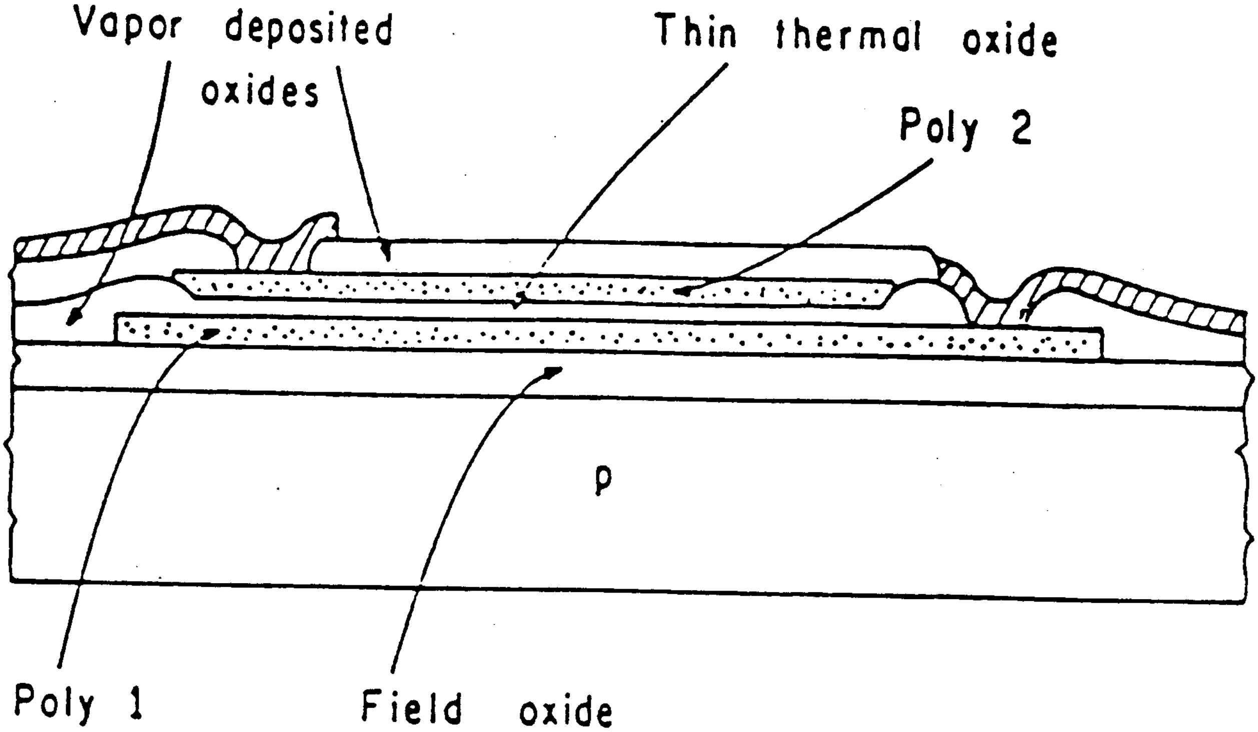


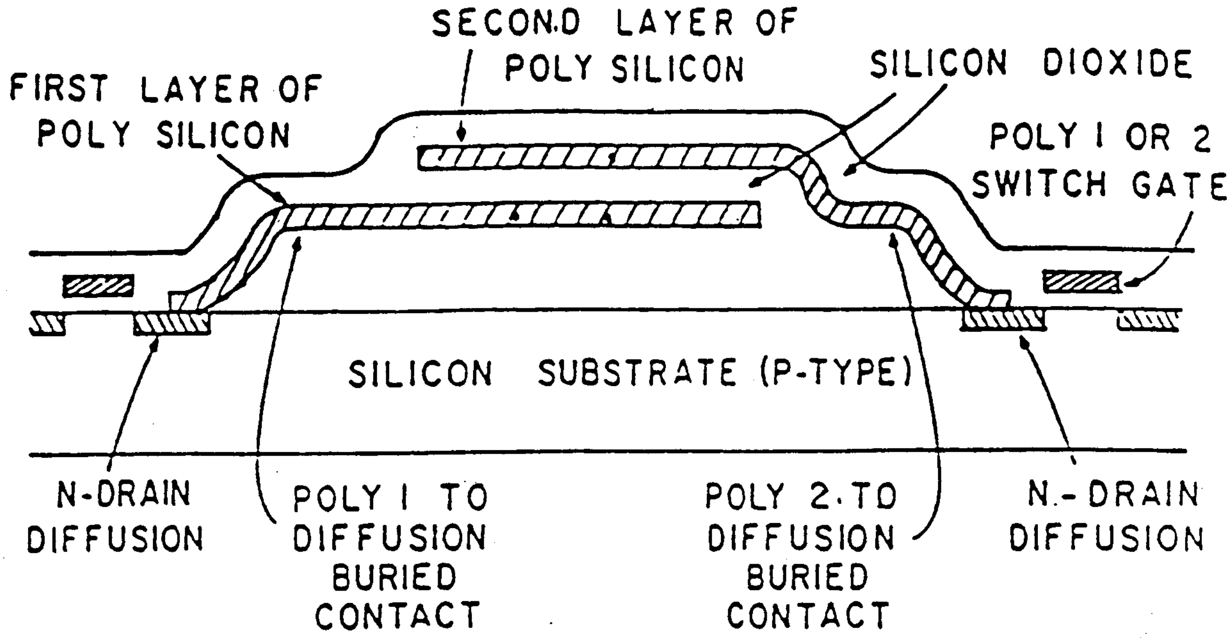
Fig: Capacitor uses two layers of polysilicon. The dielectric oxide is formed by thermally oxidizing poly 1 before depositing poly 2.

Requires double-poly

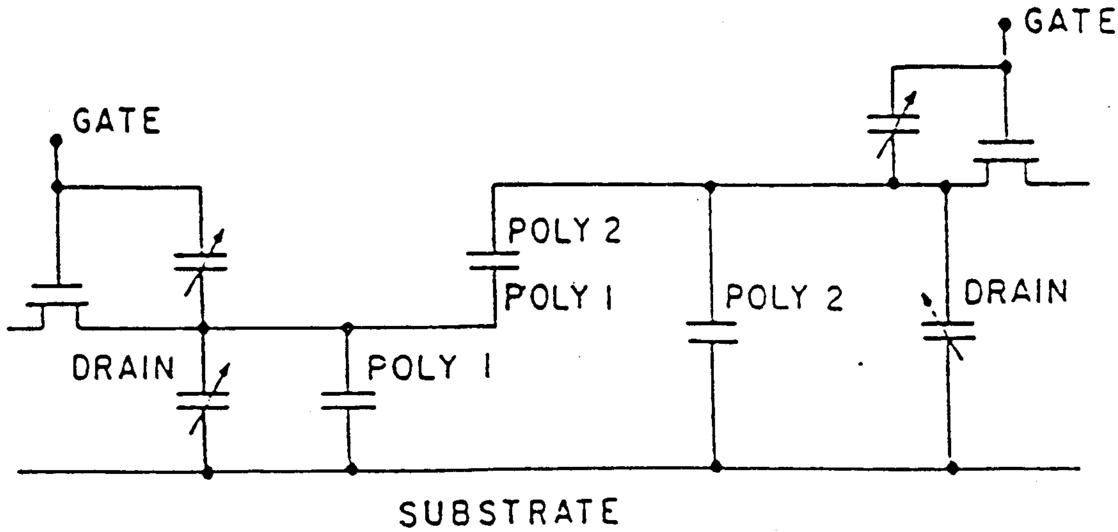
TCC ≈ 100ppm/°C

VCC ≈ 100ppm/V

Polysilicon Capacitor and Switch Structure



CIRCUIT MODEL



Component Matching Data

Component	Fabrication technique	Matching	Temperature coefficient	Voltage coefficient
Resistors	Diffused	±0.4%	+2000ppm/°C	~200ppm/V
	Ion-implanted	±0.12%	+400ppm/°C	~800ppm/V
Capacitors	MOS $t_{ox} = 0.1\mu$	±0.06%	26ppm/°C	10ppm/V

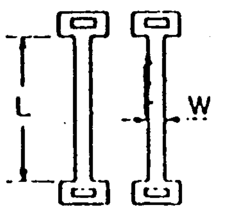
Component Matching Considerations

a) Lithographic Resolution Limit

Resistors $R = R_S \frac{L}{W}$ $R_S : \Omega/\square$

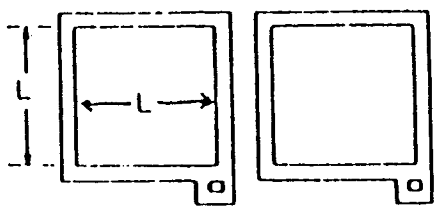
$$\frac{\Delta R}{R} = \frac{\Delta L}{L} - \frac{\Delta W}{W}$$

$$\boxed{\frac{\Delta R}{R} \cong \frac{\Delta W}{W}}$$



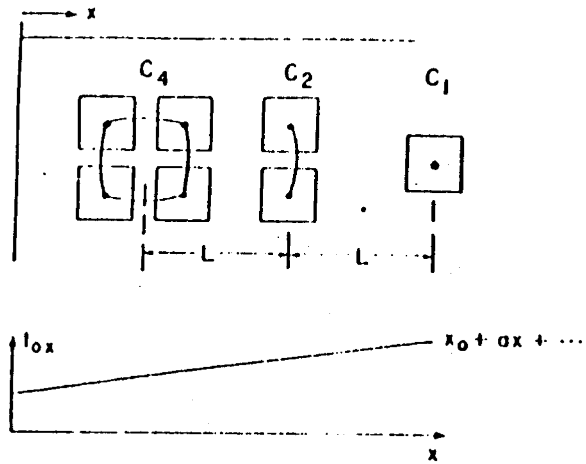
Capacitors $C = C_{OX} L^2$ $C_{OX} : pF/mil^2$

$$\boxed{\frac{\Delta C}{C} = 2\frac{\Delta L}{L}}$$

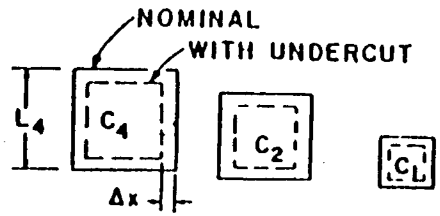


Key point: Use large geometries

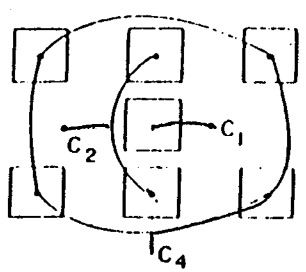
Gradient Insensitive Structures



Undercut Insensitive Structures



Common Centroid Geometry



Undercut - Insensitive Geometry