Source/Drain Diffusion Resistor

Fig: Resistor formed in source-drain diffusion.

$$R_\Omega = 20 - 80 \Omega/\Omega$$
$$TCR = 500 - 1500 \text{ppm/}^\circ\text{C}$$
$$\text{Tolerance} = \pm 15\%$$
Polysilicon Resistor

![Diagram of a polysilicon resistor](image)

**Fig:** Resistor formed in polysilicon.

\[ R_0 \approx 20 - 80\, \Omega/\square \]

\[ TCR \approx 500 - 1500\, \text{ppm/}^\circ\text{C} \]

Tolerance = ± 10%

Usually denser than diffused resistor.
Well Resistor (CMOS)

Fig: "Pinched" resistor in a CMOS well.

\[ R_0 \approx 1k - 5k\Omega/\square \]

TCR \approx 4000\text{ppm}/\degree \text{C}

Tolerance \approx \pm 20\%

Large VCR
Capacitors: Metal-Diffusion

\[ C = 37 \text{fF/}\mu^2 @ 100 \text{ Å} \]

TCC \quad \approx 25 \text{ppm/°C}

Tolerance \quad \approx \pm 10\%

VCC \quad \approx 25 \text{ppm/V}
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
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

<table>
<thead>
<tr>
<th>Component</th>
<th>Fabrication Technique</th>
<th>Matching</th>
<th>Temperature Coefficient</th>
<th>Voltage Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistors</td>
<td>Diffused</td>
<td>±0.4%</td>
<td>+2000ppm/°C</td>
<td>~200ppm/V</td>
</tr>
<tr>
<td></td>
<td>Ion-implanted</td>
<td>±0.12%</td>
<td>+400ppm/°C</td>
<td>~800ppm/V</td>
</tr>
<tr>
<td>Capacitors</td>
<td>MOS ( t_{ox} = 0.1\mu )</td>
<td>±0.06%</td>
<td>26ppm/°C</td>
<td>10ppm/V</td>
</tr>
</tbody>
</table>

## Component Matching Considerations

### a) Lithographic Resolution Limit

**Resistors**

\[
R = R_s \frac{L}{W}
\]

\[
\frac{\Delta R}{R} = \frac{\Delta L}{L} - \frac{\Delta W}{W}
\]

**Capacitors**

\[
C = C_{ox} L^2
\]

\[
\frac{\Delta C}{C} = 2 \frac{\Delta L}{L}
\]

### Key point:
Use large geometries