INTEGRATED RESISTORS

A resistor in a monolithic integrated circuit is obtained by utilizing the bulk resistivity of the diffused volume of semiconductor region. The commonly used methods for fabricating integrated resistors are 1. Diffused 2. epitaxial 3. Pinched and 4. Thin film techniques.

Diffused Resistor:

The diffused resistor is formed in any one of the isolated regions of epitaxial layer during base or emitter diffusion processes. This type of resistor fabrication is very economical as it runs in parallel to the bipolar transistor fabrication. The N-type emitter diffusion and P-type base diffusion are commonly used to realize the monolithic resistor.

The diffused resistor has a severe limitation in that, only small valued resistors can be fabricated. The surface geometry such as the length, width and the diffused impurity profile determine the resistance value. The commonly used parameter for defining this resistance is called the sheet resistance. It is defined as the resistance in ohms/square offered by the diffused area.

In the monolithic resistor, the resistance value is expressed by

$R = R_s \, 1/w$ where R= resistance offered (in ohms)

R_s = sheet resistance of the particular fabrication process involved (in ohms/square)

l = length of the diffused area and

w = width of the diffused area.

The sheet resistance of the base and emitter diffusion in 200Ω/Square and 2.2Ω/square respectively. For example, an emitter-diffused strip of 2mil wide and 20 mil long will offer a resistance of 22Ω. For higher values of resistance, the diffusion region can be formed in a zig-zag fashion resulting in larger effective length. The poly silicon layer can also be used for resistor realization.
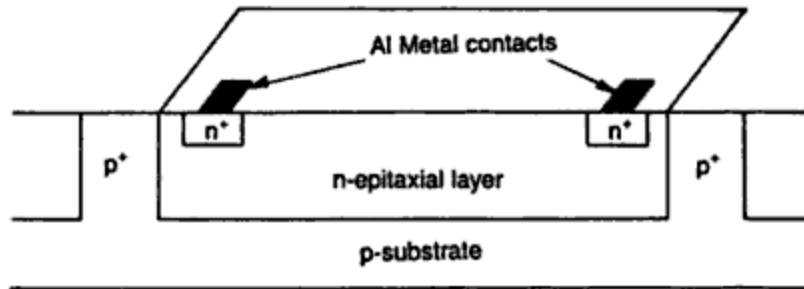
Epitaxial Resistor:

Fig. 1.23 (a) Epitaxial resistor

The N-epitaxial layer can be used for realizing large resistance values. The figure shows the cross-sectional view of the epitaxial resistor formed in the epitaxial layer between the two N^+ aluminium metal contacts.
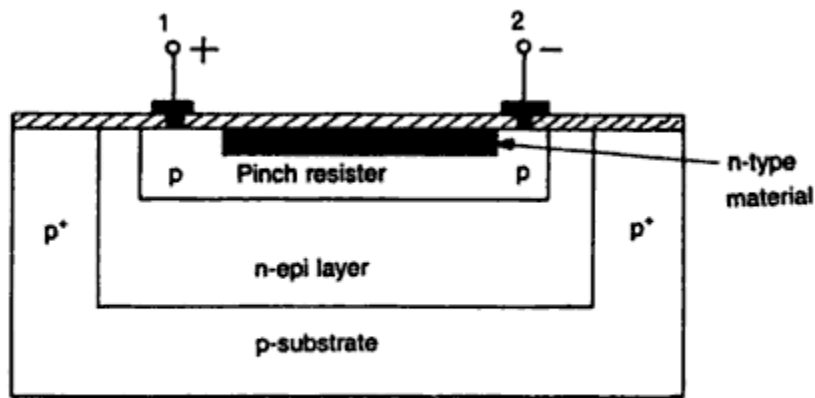
Pinched resistor:

Fig. 1.23 (b) Cross-sectional view of a pinch resistor

The sheet resistance offered by the diffusion regions can be increased by narrowing down its cross-sectional area. This type of resistance is normally achieved in the base region. Figure shows a pinched base diffused resistor. It can offer resistance of the order of mega ohms in a comparatively smaller area. In the structure shown, no current can flow in the N-type material since the diode realized at contact 2 is biased in reversed direction. Only very small reverse saturation current can flow in conduction path for the current has been reduced or pinched. Therefore, the resistance between the contact 1 and 2 increases as the width narrows down and hence it acts as a pinched resistor.
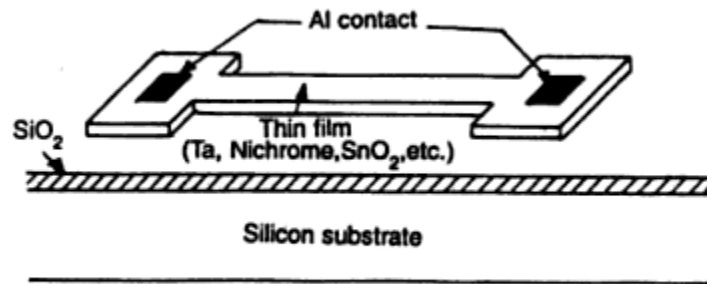
Thin film resistor:

Fig. 1.23 (c) Cross-section of a thin film resistor

The thin film deposition technique can also be used for the fabrication of monolithic resistors. A very thin metallic film of thickness less than 1μm is deposited on the silicon dioxide layer by vapour deposition techniques. Normally, Nichrome (NiCr) is used for this process. Desired geometry is achieved using masked etching processes to obtain suitable value of resistors. Ohmic contacts are made using aluminium metallization as discussed in earlier sections.

The cross-sectional view of a thin film resistor as shown in figure. Sheet resistances of 40 to 400Ω/ square can be easily obtained in this method and thus 20kΩ to 50kΩ values are very practical.

The advantages of thin film resistors are as follows:

1. They have smaller parasitic components which makes their high frequency behaviour good.
2. The thin film resistor values can be very minutely controlled using laser trimming.
3. They have low temperature coefficient of resistance and this makes them more stable.

The thin film resistor can be obtained by the use of tantalum deposited over silicon dioxide layer. The main disadvantage of thin film resistor is that its fabrication requires additional processing steps.
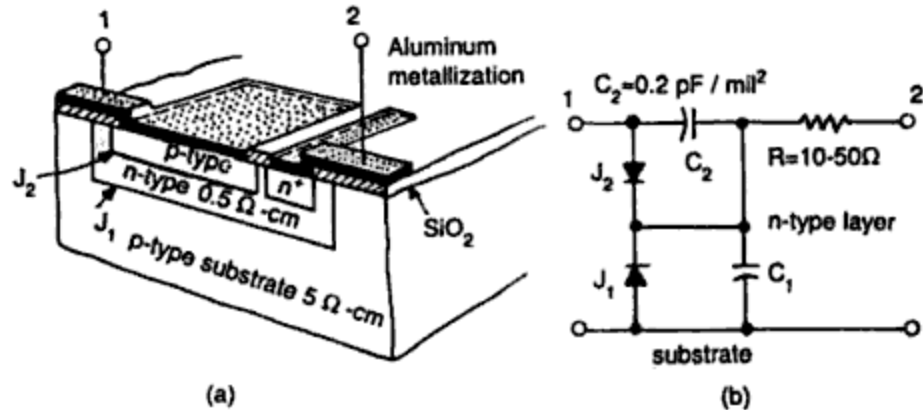
Monolithic Capacitors:

Fig. 1.24 (a) Junction-type IC capacitor, (b) Equivalent circuit

Monolithic capacitors are not frequently used in integrated circuits since they are limited in the range of values obtained and their performance. There are, however, two types available, the junction capacitor is a reverse biased PN junction formed by the collector-base or emitter-base diffusion of the transistor. The capacitance is proportional to the area of the junction and inversely proportional to the depletion thickness.

C   α A, where a is the area of the junction and

C   α T , where t is the thickness of the depletion layer.

The capacitance value thus obtainable can be around 1.2nF/mm^2.

The thin film or metal oxide silicon capacitor uses a thin layer of silicon dioxide as the dielectric. One plate is the connecting metal and the other is a heavily doped layer of silicon, which is formed during the emitter diffusion. This capacitor has a lower leakage current and is non-directional, since emitter plate can be biased positively. The capacitance value of this method can be varied between 0.3 and 0.8nF/mm^2.

Inductors:

No satisfactory integrated inductors exist. If high Q inductors with inductance of values larger than 5µH are required, they are usually supplied by a wound inductor which is connected externally to the chip. Therefore, the use of inductors is normally avoided when integrated circuits are used.