

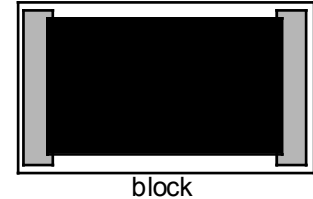


## Thick and Thin Film Resistors

### Thick film resistors

#### Materials and properties

- Composite material comprised of lead borosilicate glass and conductive phases (3-3 connectivity).
- Conductive phase can be Ag/Pd and/or ruthenium oxides ( $\text{RuO}_2$ , perovskites, and pyrochlores).
- Sheet resistance values from  $\text{m}\Omega$  to  $\text{G}\Omega$
- Typically block pattern resistor elements at all resistance values
- Screen print and fire on 96% alumina substrate
- Resistance Value Tolerance:  $\pm 1\%$  best (also 2, 5, 10, 20%, etc.)
- TCR Values:  $\pm 100$  ppm/ $^\circ\text{C}$  best (also 200, 300 ppm/ $^\circ\text{C}$  and higher)
- Noise and ESD sensitivity increases with resistance value
- Higher current capacity



#### Conduction mechanism:

- Metallic conduction within conductive phase, glassy barriers at junctions

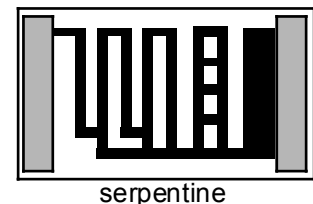
#### Failure modes:

- Resistance value increase results from over current condition. Joule heating damage to resistor film and or terminations occurs. Fractured substrate results from rapid over current and TCE mismatch.
- Resistance value decreases after exposure to excess field ( $>2\text{V}/\text{mil}$ ) due to electron tunneling across glassy barriers ( $>10000$  ohm devices).

### Thin film resistors

#### Materials and properties:

- Metal alloys and mixtures, (NiCr, Ta, TaN, etc.)
- Sheet resistance values 20 to 200  $\Omega$
- Resistor element uses block patterns at lower ( $<100$   $\Omega$ ) values, and serpentine designs at higher values ( $>100$   $\Omega$ )
- Sputter deposited on 99.6% alumina substrate, patterned using photolithography, and thermal treatment to tune TCR and resistance value
- Resistance Value Tolerance:  $\pm 0.1\%$  best (also 0.25, 0.5, 1, 2, 5, 10, 20%)
- TCR Values:  $\pm 25$  ppm/ $^\circ\text{C}$  best (also  $\pm 50$ ,  $\pm 100$ , &  $-150 \pm 50$  ppm/ $^\circ\text{C}$ )
- Low noise at all resistance values
- Lower current capacity



#### Conduction mechanism:

- Metallic conduction

#### Failure modes:

- Resistance value increase results from over current condition. Joule heating damage to resistor film and or terminations occurs. Fractured substrate results from rapid over current and TCE mismatch.
- Photolithography defects can result in resistance value increase.
- Open circuits have been found when NiCr resistors are exposed to moisture and bias. An electrochemical reaction occurs in which the resistor film dissolves.