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 (RuO₂, 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: ±1% best (also 2, 5, 10, 20%, etc.)
- TCR Values: ±100 ppm/°C best (also 200, 300 ppm/°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 (>2V/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 Ω
- Resistor element uses block patterns at lower (<100 Ω) values, and serpentine designs at higher values (<100 Ω)
- Sputter deposited on 99.6% alumina substrate, patterned using photolithography, and thermal treatment to tune TCR and resistance value
- Resistance Value Tolerance: ±0.1% best (also 0.25, 0.5, 1, 2, 5, 10, 20%)
- TCR Values: ±25 ppm/°C best (also ±50, ±100, & -150 ±50ppm/°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.