§0．Abstract

In the resistor family, thick film chip resistors are the most widely used and the most numerous types of resistors. The electrodes of thick film resistors are made and sintered from silver paste or low palladium content silver paste. In some volcanic eruption areas, farms, communication base stations, chemical plants, rubber factories, parking lots, etc., due to the relatively high concentration of sulfide gases such as SO2 and H2S, the resistors will fail due to sulfurization after a period of use. Therefore, to understand the failure mechanism of resistors and to establish reliable test methods and standards for anti-sulfurization is a necessary guarantee for improving the ability of anti-sulfurization.

§1．Types and applications of anti-sulfurized resistors

Due to the different application locations and values of electronic products, there will be different resistors to cope with different applications. Currently, there are three types of anti-sulfurized thick film chip resistors in the market. The first type is gold electrode resistors, which are completely anti-sulfurized resistors; the second type is resistors made from silver paste with high palladium content, usually with a palladium content of around 20% to 30%; the third type is resistors which achieved anti-sulfuration through material matching and structural protection.

The first two types of products have stable anti-sulfuration performance, but the cost is high; the characteristic of the third type of products is its low cost, which varies depending on the material selection and manufacturing process. Therefore, when selecting anti-sulfurized resistors, customers also need to identify the supplier's current customer group and sales volume, and confirm test conditions for anti-sulfurized resistors. The types, characteristics, and applications of anti-sulfurized products are shown in below table:

No.	Type	Characteristics	Applications
1	Gold electrode	Complete anti-sulfurization, with a high cost	Applied to aerospace, aviation, and military industries
2	High palladium content	Containing 20% to 30% palladium, it has high anti-sulfurization and high cost	Applied to control units such as military industry, special exploration equipment, automotive engines, ABS, and tank oil level detection;
3	Structural protection	Achieving anti-sulfurization performance through structural protection and material matching	Communication base stations, air conditioning, car peripherals, medical equipment, chemical plants, farm equipment, industrial control equipment, etc.

§2． Reliability Design of Resistor Anti-Sulfurization Test Method

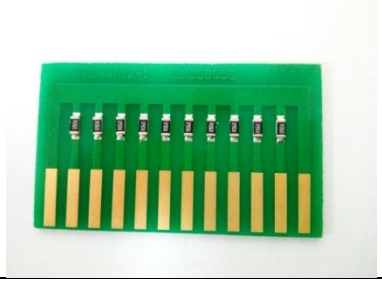
Anti-sulfurization is not a new issue, but it has been widely recognized by electronic product manufacturers in the past 10 years. Currently, there are two main schools of anti-sulfurization test in the resistor industry. One is resistor manufacturers represented by Europe and America, using the anti-sulfurization test method of ASTM-B809, and the other is resistor manufacturers represented by Japan, The oil bath test used is to immerse the resistor in gold processing oil with 3.5% sulfur powder, and then place the resistor in an environment of 105 ℃ for 500H.

The above two test methods are widely recognized and accepted by the market. However, in terms of the structure, application, and reliability design of resistors, directly using the above test conditions for anti-sulfurization test still has certain drawbacks. This is mainly because resistors are composed of different materials, and the combination of different materials may produce defects under different environmental stresses. Therefore, when designing reliability, it is necessary to consider the maximum environmental stress that the resistor may withstand from the installation and application aspects. Prior to the anti-sulfurization test, a preset test of the maximum environmental stress during installation and application should be conducted to ensure product quality and reduce the possibility of product failure. UR’ s anti-sulfurization preset test involves three reflow soldering tests on the tested resistors, then thermal shock tests at -55 ℃ for 30 minutes and 155 ℃ for 30 minutes for 100 cycles. The former corresponds to potential defects during installation, while the latter corresponds to the maximum environmental stress present in the resistors during the application process.

§3．UR’s Anti-Sulfurization Test Method on Resistors

Both of the two popular anti-sulfurization test methods in the industry can be tested in UR, and the specific test methods are as follows:

A. Test method for oil bath: this method mainly applies to NS and NQ products

No.	Test steps	Pictures	Test requirements
1	Requirements for PCB board		1. PCB board should be ENIG or Nickel plating 2. Resistor welding should use reflow soldering, and the soldering height should not exceed C1 surface
2	Reflow soldering		1. Set the temperature and speed of the reflow soldering furnace according to standards; 2. The test PCB board needs to undergo 3 reflow soldering cycles
3	Thermal shock		Thermal shock:100 Cycles Step 1:-55℃±3℃ 30min; Step 2:room temperature, 10min~15min; Step 3:155℃±2℃ 30min Step 4:room temperature, 10min~15min
4	Oil bath test		1. Add 3.5% Sublimation sulfur into gold processing oil. 2. Immerse the PCB board that has been pre-tested into gold processing oil. 3.Place the beaker in the oven and heat it to 105 ℃, then continue heating for 500H. 4.Judgment standard: ≤ ± 5%

Reliability design and test standard for anti -sulfurization tests

B. ASTM-B809: this test is mainly applies to HQ and CQ products

No.	Test steps	Pictures	Test requirements
1	Requirements for PCB board		1. PCB board should be ENIG or Nickel plating 2. Resistor welding should use reflow soldering, and the soldering height should not exceed C1 surface
2	Reflow soldering		1.Set the temperature and speed of the reflow soldering furnace according to standards; 2.The test PCB board needs to undergo 3 reflow soldering cycles
3	Thermal shock		Thermal shock:100 Cycles Step 1:-55℃±3℃ 30min; Step 2: room temperature, 10min~15min; Step 3:155℃±2℃ 30min Step 4: room temperature, 10min~15min
4	ASTM -B809		1. Add 200g of water and 200g of potassium nitrate to the bottom of the dryer 2. Place a tray filled with sulfur powder on the dryer partition 3. Hang the PCB board that has been pre-tested above the sulfur powder 4. Put a lid on the dryer and place it in a 60 ℃ oven, with an internal temperature and humidity condition of 60 ℃ 85% RH ± 4% RH; 5. Take it out and measure resistance value after 1000H; 6. Judgment standard: ≤ ± 1%