INFLUENCE OF TOPOLOGY ON RELIABILITY OF THIN FILM RESISTORS

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Abstract: *In the paper some failure mechanisms of thin film resistors are investigated. A series of experiments determining the rise of total failure in different topological resistor design depending on dissipation power and current density is made. It was established that the appearances of failure in resistors depend on rate of electric load change. Different failure mechanisms were examined according to topological design and electrical power.*

1. Introduction

The reliability of electronic equipment is a key factor for the normal operation of modern manufacturing processes as far as it is based mainly on electronic control. This sets serious requirements to the investigation of failure mechanisms in electronic equipment and increasing of its reliability.

2. Problem description

Hybrid integrated circuits are used in a great number of electronic equipment as they meet the requirements for miniaturization of units. To achieve this it is necessary to design passive components which operate in a heavy environment. Thus the investigation of failure mechanisms of thin film resistors in HIC is very important.

3.Theoretical basis

The reliability of thin film resistors were always paid great attention. The main criteria for achieving of high reliability is power load, i.e. temperature mode [1].

The resistor design is based on the parameter admissible dissipation power per unit area P_{adm}. This parameter is related to the substrate characteristics and thermal resistance layer/substrate.

The influence of the shape and area on the admitted dissipated power is examined in [2], assuming that the area is the key parameter.

Investigations on the failure mechanism in thin film resistors and their relation to the substrate are performed in [3]. The mechanism of thermal destruction of thin film is examined. This type of destruction is observed mainly in the centre of the resistor, due to the maximum temperature in this zone. This is proved by the view of thermal distribution in a loaded resistor [4] - Fig. 1.

It is well known that the current lines are not uniformly distributed along the thin film resistors [5], especially if their topology is complex. This results into unequal heating and failures.

4. Experimental results

Having in mind the above considerations, the authors performed a series of experiments to determine the thin film reliability.

In this case the reliability could be assumed as long-term stability of one parameter, total failure or considerable non-recoverable change of a parameter after eliminating the load. The attention was concentrated on the last two cases, having in mind also the influence of the topology. The topology in Fig. 2 could be classified in two groups - linear and non-linear.

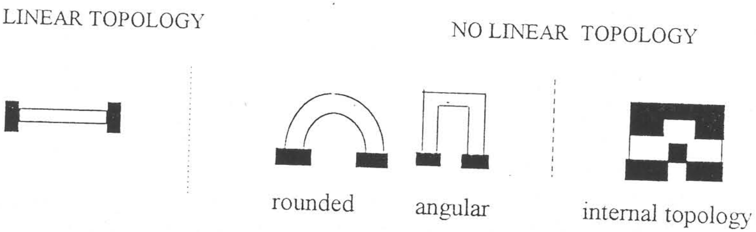

Figure 2.Topological groups of thin film resistors

Experiments were performed under voltage stress of the resistors after which the current was measued and the dissipated power or current density per unit resistor width are calculated

Experiments were performed for NiCr resistors, deposited on sital substrate with sheet resistance $R_s = 130\text{-}160\Omega/\square$. Power stress 60-90 W/cm^2 for resistors in angular shapes and 100-130 W/cm^2 for resistors in rounded shapes.

Additional mechanism is the stage development of breakdowns. Breakdown is observed under definite voltage, burning part of the layer, thus increasing the resistance, the current decreases and stabilisation is observed. The further increase of the voltage new breakdowns are observed - on different zones.

As a result of the experiments is was found that the resistor failure depends not only on the load power, but also on the rate of increasing the load. For instance, for internal topology several breakdowns are observed along the line of highest electrical stress - Fig.3.

For outer topologies (rounded or angular) there is a clear differentiation of the failure mechanism and the rate if increase of the load. For rapid increase of the load higer than 15 V/cm in angular shapes destruction along the line of electrical tension of the field is observed - Fig. 4 and Fig. 5.

If the rate of load is near, but higher than the thermal tie constant of the substrate, thermal breakdown of the resistance layer (local evaporation-oxidation) is observed - Fig.6.

For low rates (V < 1 V/s) up to high power, low mechanical strength and thermal conductivity of the substrate mechanical destruction (cracking) of the base is observed - Fig.7.

5. Conclusion

For the design of thin film resistors under high load the influence of the topology of the failure should be considered, i.e. the possibility for catastrophe failure should be considered These effects are less dangerous for heat conducting substrates

References:

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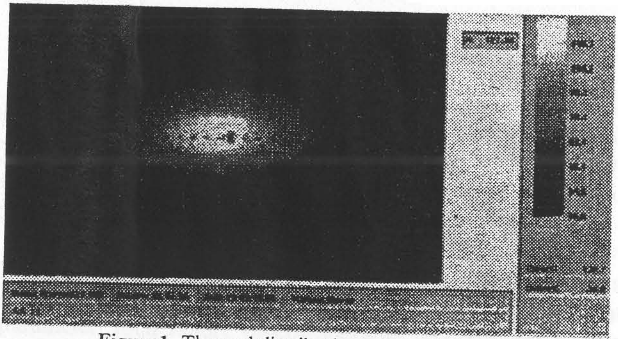

Figure1. Thermal distribution in a loaded resist

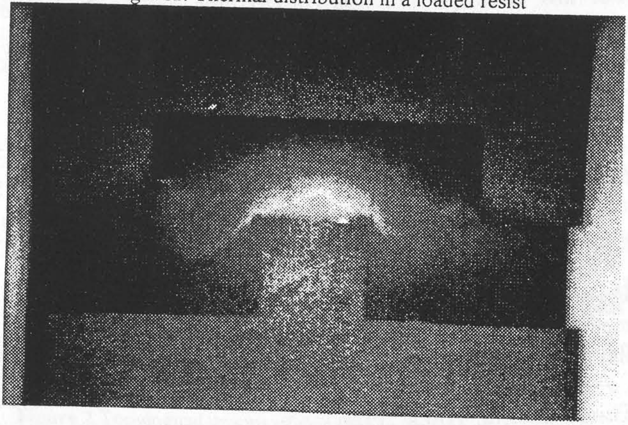

Figure 3. Breakdown in a electrical loaded resistor

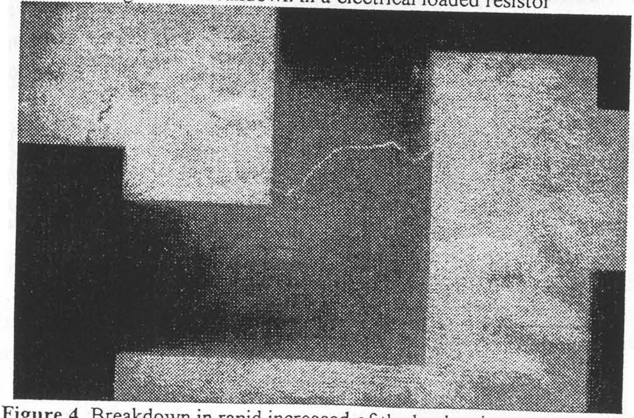

Figure 4. Breakdown in rapid increased of the load resistor with angular shapes

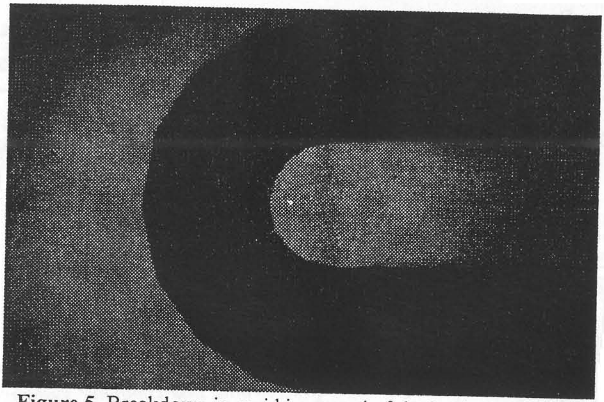

Figure 5. Breakdown in rapid increased of the load resistor with rounded shapes

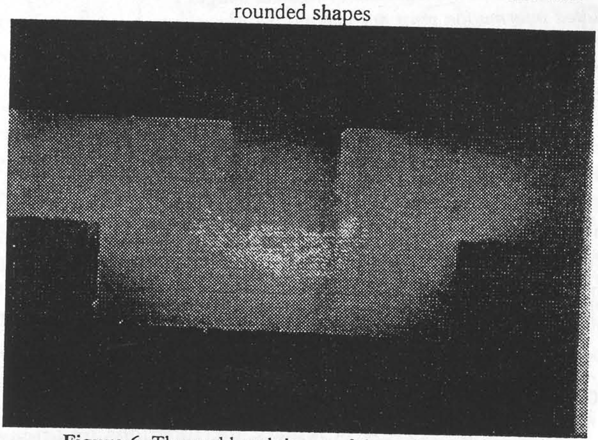

Figure 6. Thermal breakdown of the resistance layer

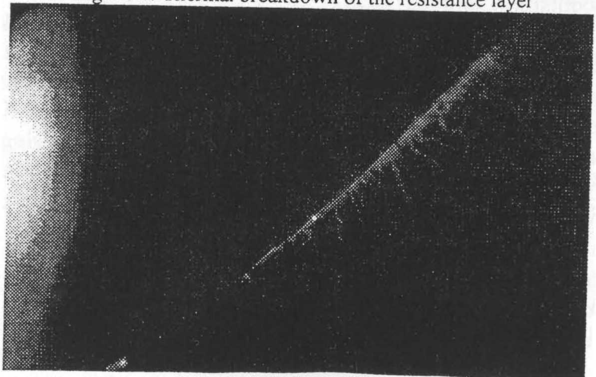

Figure 7. Substrate mechanical destruction