ELECTRICAL RESISTOR HAVING LOW RESISTANCE VALUES

Filed Oct. 10, 1967

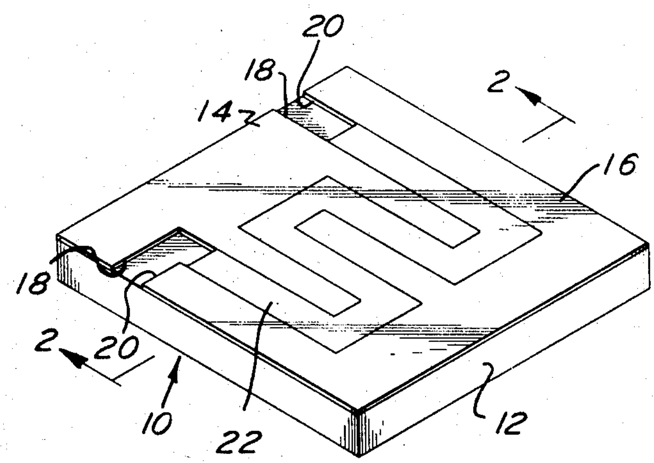

FIG. 1

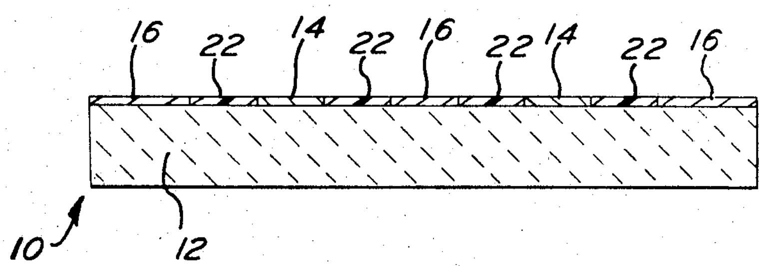

FIG. 2

INVENTOR
WILLIAM A. MULLIGAN
BY Donald S. Olson
ATTORNEY

United States Patent Office

3,473,146
Patented Oct. 14, 1969

1

3,473,146
ELECTRICAL RESISTOR HAVING LOW RESISTANCE VALUES

William A. Mulligan, Willingboro, N.J., assignor to TRW Inc., a corporation of Ohio

Filed Oct. 10, 1967, Ser. No. 674,321
Int. Cl. H01c 3/00
U.S. Cl. 338—293 4 Claims

ABSTRACT OF THE DISCLOSURE

An electrical resistor comprising a substrate of an electrical insulating material having on a surface thereof a pair of termination films of an electrically conductive metal and a film of an electrical resistance material extending between and contacting opposed edges of the termination films. The distance across the resistance film between the opposed edges of the termination films is much less than the distance along the opposed edges of the termination films contacted by the resistance film so that the electrical width of the resistance film is much greater than its electrical length. This provides an electrical resistor having a resistance film of less than one electrical square so as to achieve a low resistance value, preferably one ohm or less.

BACKGROUND

One type of electrical resistor which is presently manufactured is a film type resistor which comprises a film of a resistance material coated on the surface of a substrate of an electrical insulating material, such as glass, ceramic or plastic. In the manufacture of such a resistor, it is desirable to be able to provide a resistor of any desired resistance value over a wide range of resistance values. The resistance value of such a resistor is a function of the resistivity of the resistance material and the length and width of the resistance material film. An electrical resistor, in addition to having a desired resistance value, must also have other electrical characteristics. For example, the resistor must be stable with regard to the voltage applied and, to change in temperature, must be able to withstand the load to be applied to the resistor, and must have a good shelf life. In general, these other electrical characteristics are a function of the particular resistance material used. Therefore, it is the practice to use a resistance material which provides the desired other electrical characteristics for the resistor, which material has a fixed electrical resistivity, and to provide the desired resistance value by varying the length and width of the resistance film.

When using a substrate which is cylindrical, the common method of achieving a desired resistance value is to provide the resistance film as a long, narrow path which extends helically around the cylindrical surface of the substrate. By varying the length and width of the path, a wide variety of resistance values can be obtained as measured between the ends of the path. If a flat substitute is used, the same effect is achieved by providing the resistance film as a long, narrow path which meanders over the surface of the substrate. Although these techniques of making an electrical resistance permit the obtaining of a wide range of resistance values, they do not lend themselves to providing resistors of very low resistance values, particularly resistance values of approximately one ohm and less. Also, using these techniques, it has been found to be difficult to provide a resistor of very low resistance value which also has a low power density so as to provide a resistor which dissipates a relatively high power for its size.

2

SUMMARY

It is an object of the present invention to provide a novel film type electrical resistor.

It is another object of the present invention to provide a film type electrical resistor having a very low resistance value, particularly a resistance value of one ohm or less.

It is still another object of the present invention to provide a film type electrical resistor having a very low resistance value and a relatively low power density.

It is a further object of the present invention to provide an electrical resistor of the type having a film of resistance material coated on a substrate with the electrical width of the resistance film being much greater than the electrical length of the resistance film so that the resistor has a very low resistance value.

Other objects will appear hereinafter.

BRIEF DESCRIPTION OF DRAWING

For the purpose of illustrating the invention, there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIGURE 1 is a perspective view of the electrical resistor of the present invention.

FIGURE 2 is a sectional view taken along line **2—2** of FIGURE 1.

DESCRIPTION OF INVENTION

The electrical resistor of the present invention utilizes a film of an electrical resistance material which has an electrical width much greater than its electrical length so as to achieve a resistor having a low resistance value. The resistance value of film type electrical resistors is equal to the resistivity of the resistance material in ohms per square times the number of squares of the resistance film. The number of squares of the resistance film is equal to the electrical length of the resistance film divided by the electrical width of the resistance film. Thus, by having a resistance film which has an electrical width much greater than its electrical length, the number of squares of the resistance film is less than one so that the resistance value of the resistor is only a fraction of the resistivity of the resistance material used for the film. For example, if the electrical width of the resistance film is 10 times the electrical length of the resistance film, the resistance film is 0.1 electrical square. If the resistivity of the resistance material used for the resistance film is 10 ohms per square or less, the resistance value of the resistance is 1 ohm or less.

Referring to FIGURE 1, an electrical resistor of the present invention is generally designated as **10**. As shown, resistor **10** comprises a flat, square substrate **12** of an electrical insulating material, such as a glass, a ceramic or a plastic. On one surface of the substrate **12** are a pair of termination films **14** and **16** of an electrically conductive metal, such as copper, silver or gold. The termination films **14** and **16** have edges **18** and **20**, respectively, which are closely spaced from each other and follow a meandering path. The edges **18** and **20** are uniformly spaced from each other along the entire width of the termination films **14** and **16**. A film **22** of an electrical resistance material is provided on the surface of the substrate **12** in the space between the opposed edges **18** and **20** of the termination films **14** and **16**. The resistance film **22** contacts both the termination films **14** and **16** along the entire extent of the resistance film. Thus, the resistance film **22** follows the meandering path of the edges **18** and **20** of the termination films **14** and **16** and is electrically connected between the termination films. The resistance film **22** may be of any well-known resistance material, such as carbon, a metal, a metal alloy, or a mixture of conductive particles in a binder of glass or a plastic. Although the substrate 12 is shown as being a flat plate, it can also be a cylindrical rod or tube with the termination films 14 and 16 and the resistance film 22 being provided on the cylindrical surface of the substrate.

In the use of the electrical resistor 10, the electrical current passes through the resistance film 22 from one of the termination films to the other termination film, for example, from termination film 14 to termination film 16. Also, the electrical current will pass through the resistance film 22 from along the entire extent of the edge 18 of the termination film 14 to the entire extent of the edge 20 of the termination film 16. Therefore, the distance across the resistance film 22 between the edges 18 and 20 of the termination films 14 and 16 is the electrical length of the resistance film and the distance along the meandering edges 18 and 20 of the termination films 14 and 16 that is contacted by the resistance film 22 is the electrical width of the resistance film. Thus, the resistance film 22 has an electrical width substantially greater than its electrical length so as to be less than one electrical square and provide a resistor of low resistance value. For example, on a substrate ½" by ½", a resistance film 22 which has an electrical length of .05" and an electrical length of 1.65" results in .033 electrical square. If the resistance material of the resistance film has a resistivity of 10 ohms per square, the resulting resistor 10 has a resistance value of 0.33 ohm. If the resistance material has a resistivity of 1 ohm per square, which can be easily obtained, the resulting resistor has a resistance value of 0.03 ohm.

Although the opposed edges 18 and 20 of the termination films 14 and 16 are shown as following a meandering path, they can also be straight and parallel as long as the distance between the edges 18 and 20 is much less than the distance along the edges that is contacted by the resistance film 22 so as to provide a resistance film of less than one electrical square. However, having the edges 18 and 20 follow a meandering path is preferable since it provides for a resistance film 22 having the longest electrical width for the size of the substrate 12. Although the number of electrical squares of the resistance film 22 can be decreased by decreasing the electrical length of the resistance film as well as by increasing its electrical width, it is preferable to do so by increasing the electrical width of the resistance film. The permissible power which can be dissipated across the resistance film 22 is determined by the surface area of the resistance film. Thus, the greater the surface of the resistance film, the lower the power density and the higher the total power that can be dissipated by the resistance film. Therefore, the larger the electrical width and length of the resistance film 22, the larger its surface area. Thus, it is preferable to obtain the desired number of electrical squares by using a resistance film that has a relatively larger electrical length but a much larger electrical width. On a given size substrate, this is easiest achieved by having the edges of the termination films follow a meandering path. Also, in general, many of the electrical characteristics of low resistivity resistance materials improve as the resistivity is increased. Thus, a resistance material having a resistivity of 10 ohms per square may have better electrical characteristics over a resistance material of the same composition which has a resistivity of one ohm per square. Thus, it is desirable to use for the resistance film 22 a resistance material having the highest possible resistivity. By decreasing the number of electrical squares provided by the electrical film 22, which can be easiest achieved by increasing the electrical width of the resistance film, a higher resistivity resistance material can be used to achieve a resistor of the desired resistance value. Therefore, for the resistor of the present invention which has a low electrical resistance, the meandering path of the edges 18 and 20 of the termination films 14 and 16 is preferred to obtain a highly electrically stable resistor which can dissipate high electrical power.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. An electrical resistor having a low resistance value comprising a substrate of an electrical insulating material, a pair of termination films of an electrically conductive metal on a surface of the substrate, said termination films having opposing edges in closely spaced relation, a film of an electrical resistance material on said surface of the substrate and extending only between the opposed edges of the termination films, said resistance film contacting both of said terminations, and the electrical length of the resistance film between the termination films being smaller than the electrical width of the resistance film along the opposed edges of the termination films so that the resistance film is less than one electrical square.

2. An electrical resistor in accordance with claim 1 in which the spacing between the opposed edge of the termination films is uniform along the entire extent of the resistance film.

3. An electrical resistor in accordance with claim 2 in which the resistance film contacts the termination films along its entire extent along the edges of the termination films.

4. An electrical resistor in accordance with claim 3 in which the opposed edges of the termination extend along a meandering path.

References Cited

UNITED STATES PATENTS

2,609,688	9/1952	Larach	338—309 X
2,886,476	5/1959	Dumesnil	338—309 X
3,391,373	7/1968	Altman	338—308

B. A. GOLDBERG, Primary Examiner

U.S. Cl. X.R.

338—308, 309, 322