

March 11, 1969

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3,431,640

METHOD FOR ADJUSTING THIN FILM RESISTORS

Filed March 4, 1966

FIG. 1

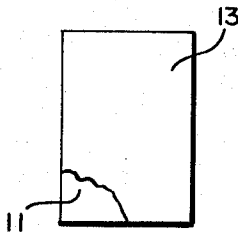


FIG. 2

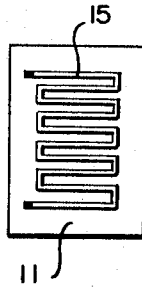


FIG. 3

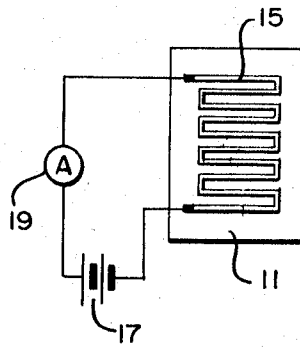


FIG. 4

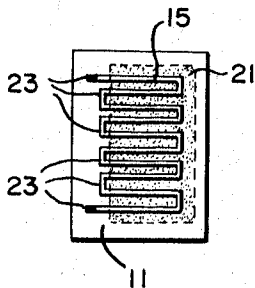


FIG. 7

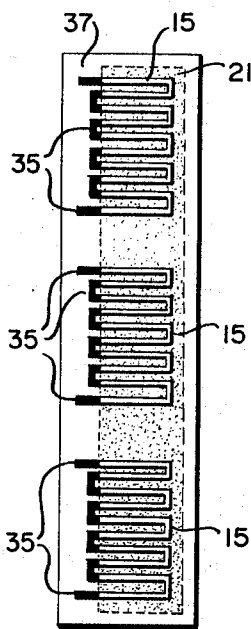


FIG. 8

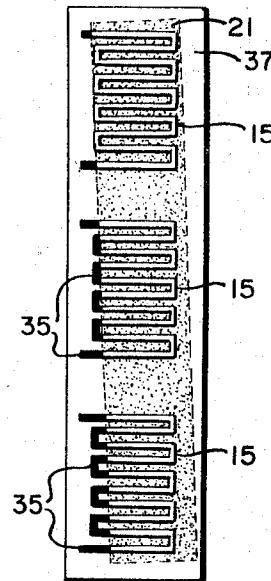


FIG. 5

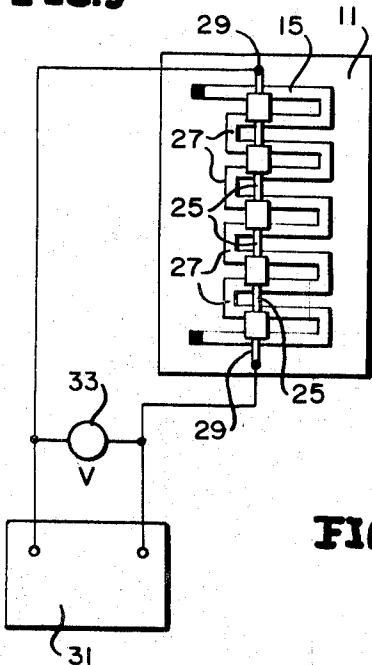
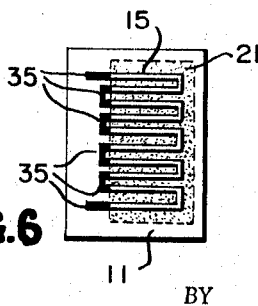


FIG. 6



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METHOD FOR ADJUSTING THIN FILM RESISTORS
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Filed Mar. 4, 1966, Ser. No. 531,999

U.S. Cl. 29-620

8 Claims

Int. Cl. H01c 9/00, 17/00

ABSTRACT OF THE DISCLOSURE

This invention relates to a method for adjusting the resistance of thin film resistors to bring them within tolerance by coating a non-conducting substrate with a uniform film of resistive material, removing all of said resistive material except for a pattern of continuous conductive lines, determining the amount of the resistance of the lines within tolerance, coating the determined amount of the resistive material with a protective coating and shorting out the exposed portion of the resistive material by coating with a good conductor.

This invention relates generally to methods for making thin film resistors and more particularly to methods for trimming thin film resistors to bring them within tolerance.

Thin film resistors of various types find wide use in printed circuits and many other types of electronic equipment. Cermet resistors have been used most frequently in these applications because they are relatively inexpensive. These resistors, however, have several disadvantages, among which are high noise index, high thermal coefficient of resistivity, and high drift. They also experience fairly substantial degradation when used at high temperatures for any length of time.

Thin film resistors of tin oxide do not possess these disadvantages. However, because they are more expensive, they have not been used as widely as cermet except in precision or high temperature applications where their better characteristics are essential.

Manufacturing and processing costs are important factors contributing to the cost of thin film resistors. Until now tin oxide resistors could be prepared only by individual processing with no use of more advantageous and less expensive mass production methods. It has been known that if the manufacturing costs of tin oxide resistors could be reduced, it would reduce or even eliminate the cost differential between them and cermet resistors.

In preparing tin oxide thin film resistors, it is relatively easy to deposit a coating of resistive material which is uniform over the substrate. It is impracticable, however, to deposit the exact thickness of resistive material necessary to have the desired value of resistance except in some cases by continuous monitoring during the preparation process. To do this is most inconvenient and expensive, and, in many processes, impossible. It is necessary, therefore, in most processes for making thin film resistors, to perform trimming operations on the resistive material after the deposition process is completed in order either to increase or to decrease the resistance to bring it within the close tolerances necessary. Prior methods have usually consisted mainly of grinding portions of the resistive material away to increase path length and thereby increase resistance. These methods have not been found to be adaptable to use in mass production methods of manufacturing resistors and so are too expensive for ordinary use.

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It is, therefore, the primary object of my invention to reduce the manufacturing cost of tin oxide thin film resistors.

It is another object of my invention to reduce the cost of manufacturing tin oxide thin film resistors by providing a method for preparing them with mass production methods.

A further object of my invention is to provide a method for making inexpensive thin film resistors having good thermal, noise, and drift characteristics.

In carrying out these and other objects of my invention I provide an improved method for trimming thin film resistors to bring them within tolerance. The method comprises the steps of determining the portion of the resistor to be retained, applying a protective coating to that portion of the resistor, and shorting out the exposed portions of the resistor by coating them with a good conductor. A plurality of identical resistors arranged columnally on a substrate may be prepared simultaneously by applying the protective coating in a continuous line to all the resistors in a column after determining the portion to be retained of one of them.

Various other objects and advantages and features of my invention will become more fully apparent from the following specification with its appended claims and accompanying drawings in which:

FIG. 1 is a substrate having a coating of tin oxide deposited thereon.

FIG. 2 shows the substrate having all but the predetermined pattern of continuous conductive lines removed.

FIG. 3 illustrates a system for measuring the resistance of the resistive lines.

FIG. 4 shows the protective coating covering a selected portion of the conductive lines.

FIG. 5 illustrates an alternate method for determining the placement of the protective coating.

FIG. 6 shows the exposed portions of the resistive pattern coated with a good conductor.

FIG. 7 shows an arrangement whereby the method of my invention may be used to prepare a plurality of equal resistors simultaneously.

FIG. 8 illustrates how the method of my invention may be used to prepare simultaneously a plurality of resistors of varying values.

My invention can best be understood by referring to the following detailed description of the illustrated embodiment, in which the method of my invention is first described in relation to the preparation of a single resistor.

Referring to FIG. 1 in the drawings, substrate 11, which may be made out of any suitable insulating material, such as glass, is coated with a thin layer of tin oxide 13. The coating 13 may be deposited on the substrate 11 by any convenient method, for instance, by evaporation techniques.

Next, the unwanted portions of the film 13 are removed so as to leave a pattern of continuous resistive lines 15, which make up the thin film resistor as shown in FIG. 2. The pattern of the resistive lines 15 shown in the drawing is given only by way of illustration, and many other patterns would be equally suitable. The manner of removing the unwanted portions of the film 13 forms no part of this invention, and it may be accomplished in any convenient manner, for instance, by etching. If it is done by etching, a protective coating is placed over the portion of the film 13 to be retained and the unprotected

portions are then removed with a chemical solvent. Next, the protective coating is removed, leaving the desired resistive pattern 15. The pattern 15 is formed so that the value of the resistance is either within tolerance or above it, but not less than the desired value.

The resistance of the resistive pattern 15 is next determined by any suitable method, for example, as is illustrated in FIG. 3, by applying a known voltage from the voltage source 17 and reading the current in the resistor 15 with ammeter 19. Of course, many other methods for accurately measuring the resistance of the pattern 15 are well known, and any of them can be used.

After the resistance is measured, a portion of the resistor 15 is covered with a protective, non-conducting coating 21. The coating 21 is applied so that, if the resistance when measured is greater than the desired value, a fractional portion 23 of the resistor 15, equal to the amount the resistor is over the desired value divided by the total resistance, is left uncovered, as is shown in FIG. 4. This coating 21 may be of either an organic material such as diallyl phthalate, or an inorganic material such as a glass. If an organic material is used, it is usually applied as a paste by a screen process and then baked on. If an inorganic material such as glass is used, it is usually applied in a sintered form and then fired. Of course, any nonconductive coating which adheres to the resistor and gives it adequate protection may be used.

Other, more mechanized, methods are also available for determining the portion of the resistor 15 which must be shorted out in order to reduce the value of the resistance to be within tolerance. One such system is illustrated in FIG. 5. According to this method, a series of shorting bars 25 are arranged colinearly in a rigid non-conducting framework. The bars are spaced in such a manner that when the assembly is placed over the left ledge of the resistor 15, as shown in FIG. 5, they will cover the end loops 27 of the resistive material and the resistive lines on either end of the resistor 15. Electrical connections 29 are made from the end bars of the assembly to a constant current generator 31 and to a voltmeter 33.

In operation the bar assembly is placed on the left edge of the resistor 15 and then moved toward the right. As it moves toward the right, the assembly shorts out the portion of the resistor 15 to the left of it. Thus, since the current is constant, the voltage sensed by the voltmeter 33 will decrease until it reaches the level indicating that the resistance of the material to the right of the shorting assembly is within tolerance. This portion of the resistor 15 is then coated with a protective coating. Of course, the assembly can be placed at an angle with the edge of the resistor 15, if it is so desired, or, with appropriate changes in the position of the shorting bars 25, the shorting assembly can be started from the right edge of the resistor 15. If this is done, then the electrical connections for the current supply and voltmeter are made at the terminal points of the resistor 15.

As shown in FIG. 6, the exposed portions 23 of the resistor 15 are then coated with a good conductive material 35, such as copper. This shorts out the portions of the resistor so coated and reduces the resistance the amount necessary to bring it within tolerance.

Perhaps the greatest advantage of the method of my invention is that it is easily adaptable to mass production methods of making thin film resistors, thereby greatly reducing the manufacturing cost. FIG. 7 illustrates how it may be used in preparing a set of three identical resistors 15. Of course, any larger number could equally well be made in the same manner. The resistors 15 are laid out columnally on a substrate 37 in a single or multicolumn array. The resistance of one resistor 15 is measured as was done in FIG. 3. Then the protective coating 21 is applied to equal portions of all the resistors 15 by application of the protective coating 21 on the substrate 37 in a continuous line parallel to the column. The coating for

all the resistors 15 is, in this manner, applied simultaneously in a single operation while having to measure the resistance of only one of them. The proportion of the resistors 15 to be covered with the protective coating 21 is calculated in the same manner as was done for the single resistor. An alternate method for determining the portion of the resistor to be covered with the protective coating is that shown in FIG. 5. Any similar method could also be used.

Next, the exposed portions of the resistors 15 are coated with a good conductor 35, as in FIG. 6. If desired, the substrate may then be separated into parts so that each resistor is on an individual substrate.

It is relatively easy to insure that the cross-sectional area and the path length are identical for all the untrimmed resistors 15 on the substrate. Photographic processes of etching provide one method by which this can be accomplished with little difficulty. In order that the resistance of the untrimmed resistors 15 be equal, it is also important that the thickness of the resistive film on the substrate 37 be uniform over the entire surface.

If a variation in the value of the resistors is desired, the protective coating 21 can be skewed with relation to the column of resistors 15 so that different percentages of the resistors 15 are covered by the coating 21, as seen in FIG. 8. In this way, the resistive path length of each resistor 15 is different from the others, as different portions of them are shorted out with the conductor 35.

The above description of the method of embodying my invention and the materials used are by way of illustration only and are not meant to limit the scope of my invention. It would be obvious to one skilled in the art that the method of my invention is equally applicable to the preparation of any thin film resistor as long as it is possible to coat over the resistive material used.

I claim:

1. A method for trimming, to bring it within tolerance, a thin film resistor deposited on a substrate comprising the steps of

determining the portion of said resistor to be retained for bringing said resistor within tolerance, coating said portion of said resistor to be retained with a protective coating, and

shorting out the exposed portions of said resistor by coating said exposed portions with a good conductor.

2. The process of claim 1 wherein said thin film resistor is made of tin oxide.

3. The process of claim 2 wherein said good conductor is copper.

4. The method of claim 1 further including the preliminary steps of forming said resistor by depositing a uniform coating of resistive material on said substrate, and removing all of said resistive material except a pattern of continuous lines such that the resistance of said pattern is either within or above said tolerance.

5. A method for trimming, to bring them within tolerance, a plurality of thin film resistors deposited columnally on a single substrate comprising the steps of determining the portions of each of said resistors to be retained, coating said portions of each of said resistors to be retained with a protective coating, and shorting out the exposed portions of each of said resistors by coating said exposed portions with a good conductor.

6. The method of claim 5 wherein said protective coating is applied to equal portions of all of the resistors in a column in a single operation by coating in a continuous line parallel to said column.

7. The method of claim 5 further including the preliminary step of

forming a continuous line of resistive thin film material for each of said resistors of said substrate, said lines being of substantially constant width and including

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a column of identical interconnected parallel portions.

8. The method of claim 7 wherein said protective coating is applied to varying portions of all the resistors in a column in a single operation by coating in a continuous line skewed in relation to said column. 5

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