

United States Patent

Yamaguchi

[15] 3,659,339

[45] May 2, 1972

[54] METHOD OF MAKING A FILM RESISTOR

[72] Inventor: Isao Yamaguchi, Kodaira-shi, Japan

[73] Assignee: Hitachi, Ltd., Tokyo, Japan

[22] Filed: Sept. 24, 1969

[21] Appl. No.: 860,523

[30] Foreign Application Priority Data

Oct. 11, 1968 Japan.....43/73529

[52] U.S. Cl.....29/620, 338/306

[51] Int. Cl.....H01c 7/00, H01c 17/00

[58] Field of Search.....29/620, 610, 621; 338/308, 338/309, 306, 307, 217, 333

[56] References Cited

UNITED STATES PATENTS

1,975,410 10/1934 Simpson.....338/217 X

3,140,379 7/1964 Schleich et al.....219/69
3,284,878 11/1966 Best.....29/620
3,394,386 7/1968 Weller et al.....29/610 X

Primary Examiner—John F. Campbell
Assistant Examiner—Victor A. DiPalma
Attorney—Craig, Antonelli & Hill

[57] ABSTRACT

A method of making a resistor comprising the steps of depositing resistor materials onto a substrate in the form of a film and connecting conductors to the two ends thereof, wherein the said resistor film is formed so that it includes a first part where the current path between the said conductors is long and a second part where the current path is short, and first and second ditches are provided in the said first and second parts of the resistor film in a direction crossing the direction of the current so as to adjust the resistance between the said two conductors to the desired values.

8 Claims, 8 Drawing Figures

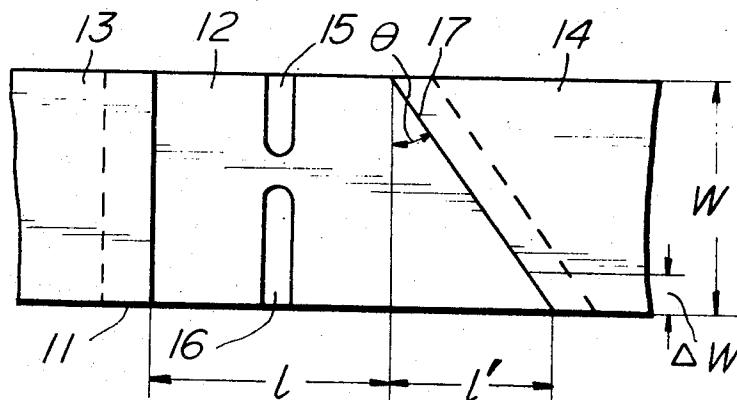


FIG. 1 PRIOR ART

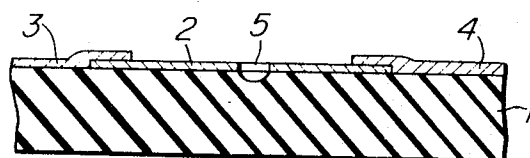


FIG. 2 PRIOR ART

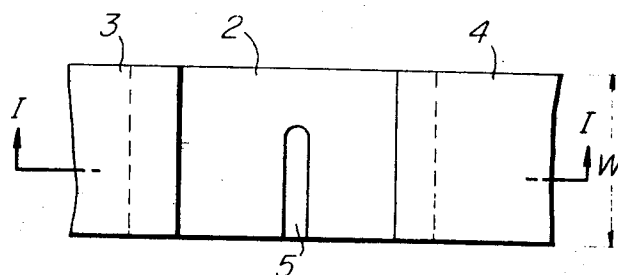
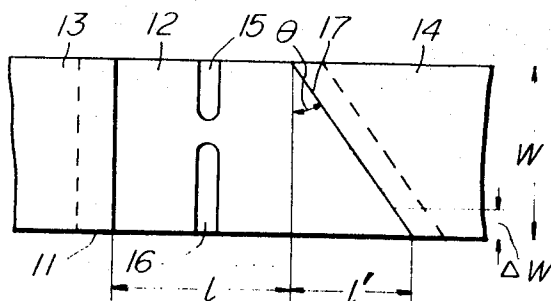
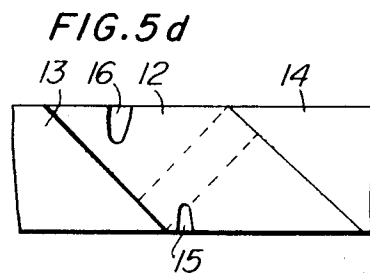
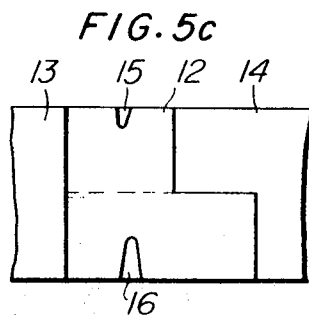
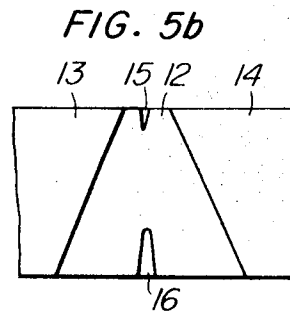
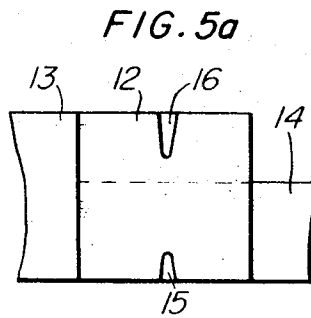
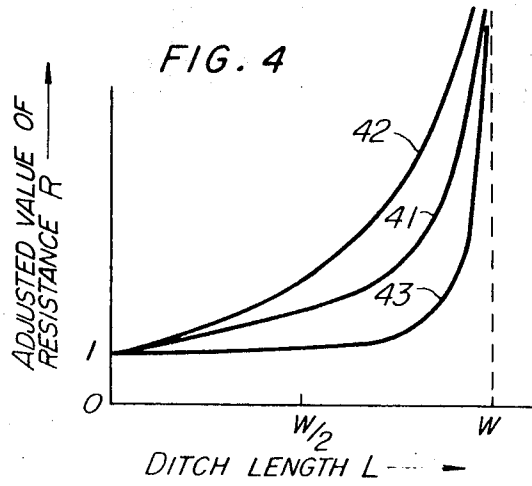


FIG. 3





METHOD OF MAKING A FILM RESISTOR

This invention relates to a method of making a film resistor and more particularly to a film resistor for a printed circuit wherein the resistance can be adjusted accurately and quickly.

Film resistors have conventionally been used for an integrated circuit device, a printed circuit and the like. Such film resistors include thick film resistors which are formed, for example, by printing, and thin film resistors which are made by sputtering, vacuum deposition etc. onto an insulator and distinguished from the former solely by film thickness.

In a miniature electronic device comprising such film resistors, e.g., a hybrid integrated circuit or a printed circuit, it is important to adjust the characteristics of the whole circuit. Resistors are very often used for such adjustments. It is frequently necessary in such cases to increase the value of the resistance of the film resistor just after fabrication by three to five times or more. In adjusting resistance values, with a conventional resistor, there is employed a method called "trimming" wherein a ditch across the current path is provided at a part of the resistor to make the effective width of the resistor small and thereby increase the resistance. Though the details are described below with reference to the accompanying drawings, it was difficult to set the resistance value to a desired value. Further, this method has an economic disadvantage and a disadvantage in the thermal characteristics of the resistor because a large amount of resistor materials must be eliminated to obtain a resistor having the desired value of resistance.

An object of this invention is to provide a method of making a film resistor having the desired value of resistance with a high precision.

Another object of this invention is to provide a simple method for the fine adjustment of the resistance of a film resistor.

A further object of this invention is to provide a method of making a film resistor having a desired value of resistance by eliminating only a small amount of resistor materials.

There is provided according to an embodiment of this invention a method of making a film resistor which comprises the following steps. Firstly, a substrate having an insulating surface is prepared. Then, there is formed on said surface a resistive film which bridges the first and second electrodes and comprises the first and second resistance paths. In this case, the resistance of the said first resistance path must be made larger than that of said second resistance path. Lastly, a part of at least one of the said first and second resistance paths is eliminated to adjust the resistance of the film resistor between the said two electrodes to a predetermined value. When the said resistor is provided in the predetermined circuit unit as described above, the characteristics of the whole circuit can naturally be adjusted.

Other objects, features and advantages of this invention as well as the foregoing objects will become more apparent from the following detailed description of the invention when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a sectional view of an example of a conventional film resistor taken along the line I—I of FIG. 2,

FIG. 2 is a plan view of the conventional film resistor shown in FIG. 1;

FIG. 3 is a plan view showing an embodiment of a film resistor according to this invention;

FIG. 4 is a diagram showing the relation between the length of the ditch and the adjusted value of the resistance of a film resistor; and

FIGS. 5a to 5d and plan views showing the other embodiments of a film resistor according to this invention.

For a better understanding of this invention, a conventional example will be described. A film resistor is shown in FIGS. 1 or 2, wherein a resistive film 2 is formed on the insulating surface of a semiconductor or insulator substrate 1 and electrode conductors 3 and 4 are connected to the two ends of the resistive film 2,

Such a resistor has widely been used as a component for an integrated circuit, etc.

When the original value of the resistance has to be increased by three times for example, the length of the ditch 5 is made to be two-thirds W as shown in FIG. 2 so that about one-third of the resistor width W remains. Now, the rate of increase of the resistance actually adjusted rises rapidly as the length of the ditch 5 approaches the width W of the resistor as shown by curve 41 of FIG. 4. Accordingly, fine adjustment of the resistance value becomes extremely difficult as the ditch 5 becomes longer.

Further, the maximum allowed power of the resistor is limited by the permitted temperature rise of the resistor which depends on the thermal conductivity of the substrate, the ratio of the effective area of the resistor to the total area of the substrate and the cooling mechanism employed. Therefore, if a relatively large amount of resistor material is eliminated to obtain a large resistance, the effective area of the resistor decreases. Thus, heat dissipation is not facilitated and the maximum power allowed decreases.

Now, embodiments of this invention will be described in detail.

FIG. 3 is a plan view of a film resistor according to an embodiment of this invention. In the figure, 11 is a substrate made e.g. of ceramics on which the film resistor is mounted, 12 is a quadrilateral resistive film made e.g., of tantalum, an alloy of nickel and chromium, cermet, etc., which is deposited on the said substrate by printing, vacuum deposition, cathode sputtering, etc. and which has an oblique side 17 such that the length in the current path direction is larger in one part and smaller in the other, and 13 and 14 are a pair of electrode conductors formed so that a part thereof is folded on the each end of the resistive film 12. As to their fabrication, either the electrode conductors 13, 14 or the resistive film 12 may be formed in advance, then ditches 15, 16 are formed,

In making such a resistor, since the length of the resistor is made larger at one part and smaller at the other, therefore the resistance is large on one side and becomes smaller towards the other side, the rising characteristic of the resistance by means of a ditch depends upon the position of the ditch. The value of resistance R in the trapezoidal resistor shown in FIG. 3 is derived approximately from the following formula:

$$R = \rho s \frac{l}{W} \left(\frac{1}{\frac{W}{\Delta W} + \frac{\rho s}{R_0} \tan \theta} + \frac{1}{\frac{W}{\Delta W} + \frac{2\rho s}{R_0} \tan \theta} + \frac{1}{\frac{W}{\Delta W} + \frac{\rho s}{R_0} \tan \theta} \right)^{-1}$$

where ρs is a sheet resistivity (resistance between the opposite sides in a square region having unit area and unit thickness), l is the minimum length of a resistor in the direction of current, W is a width of a resistor measured perpendicular to the direction of current, ΔW is a small width when the resistor width W is divided into n parts, $\tan \theta = l'/W$ and $R_0 = (\rho s l)/(W)$.

As is evident from the above formula, it is important to select the angle θ appropriately and a value ranging from about 20° to 70° is preferable in practice, namely, an angle of 110° – 150° with respect to the side crossing the ditch 15. It is desirable to form the ditches, which are to be provided in the said resistive film, in both sides between the conductors 13 and 14 as shown in FIG. 3, but they may be formed in either one side or the center of the resistor in a direction crossing the direction of the current.

FIG. 4 shows the relation between the adjusted value of resistance and the length of the ditch when the ditches are formed on both sides of the trapezoidal resistive film 12 as shown in FIG. 3. In this case, the width of the ditch in the direction of the current flow hardly contributes to the change of resistance. Namely, curve 42 shows the value of resistance when the ditch 15 is provided from the side of the shorter current path of the resistor and curve 43 shows the value of resistance when the ditch 16 is formed from the side of the longer current path. In the figure, 42 indicates a rate of increase nearly proportional to the length of the ditch while 43 indicates a gentler rate of increase than curve 42 until the ditch becomes quite long.

Accordingly, in the adjustment of the value of resistance, an adjusted value of resistance nearly equal to the desired one is first obtained by providing a short ditch 15 from the side of the short length by sandblasting, etc. Then, by providing a ditch 16 from the side of large length, fine adjustment of resistance is carried out so as to make the adjustment error smaller. Thus, in this embodiment, fine adjustment of resistance is made possible by forming a resistor having a plurality of parts different in resistance and providing ditches therein. Further, the adjustment of the ditch length in trimming becomes easier and the time for trimming becomes shorter.

When the ditches are formed at the center of the resistive film 12, the value of resistance is first roughly adjusted by forming a ditch in a direction crossing the direction of current towards the part where the inter-conductor distance is shorter and then the fine adjustment is carried out by forming a ditch into a direction towards the part where the inter-conductor distance is longer.

FIG. 5 shows various forms of resistive film regions of film resistors according to this invention, wherein the same parts as in FIG. 3 are denoted by the same numerals. The resistor shown in FIG. 5a is formed by setting one of the two electrodes 14 at a part of one side and providing a resistance path having a relatively low resistance at the part sandwiched by the electrodes 13 and 14 under the dotted line. FIG. 5b shows a resistor wherein the two ends of the resistive film are formed obliquely. FIG. 5c shows a resistor wherein one end of the resistor film is formed into a step form and the region sandwiched by the dotted line and the side having the ditch 15 provides a low resistance path. FIG. 5d shows a parallelogram resistor wherein the position of the ditches 15, 16 is asymmetrical. Accurate adjustments of the value of resistance is possible in these resistors for the same reason as described hereinabove. In the resistor shown in FIG. 5d, the region sandwiched by the two dotted lines forms a low resistance path. Thus, in order to obtain an L-R characteristic as shown by curves 42, 43 of FIG. 4, it is necessary to provide the ditches 15, 16 asymmetrically as Shown in FIG. 5d.

In the embodiments described hereinabove, there is described a method of making a plurality of resistance paths different in resistance wherein the inter-electrode distance is made different by planar forms, but other methods may also be employed if necessary, such as a method wherein resistivity is changed while the distance is unchanged or one wherein the distance is changed by three-dimensional forms.

I claim:

1. A method of making a film resistor comprising the steps of preparing a support substrate including an insulating principal surface, a pair of electrode conductors provided on said principal surface and a resistive film which bridges said pair of electrode conductors and includes a first resistance path and a second resistance path having a larger resistance than that of said first path; and adjusting the value of resistance of said resistive film between said pair of electrode conductors to a

desired value by eliminating at least a part of at least one of said first and second resistance paths.

2. A method according to claim 1, wherein said value of resistance is finely readjusted by eliminating a part of said second resistance path after the value of resistance is roughly adjusted by eliminating a part of said first resistance path.

3. A method of making a film resistor comprising the steps of preparing a support substrate having an insulating principal surface, forming on said principal surface a polygonal resistive film region having two sides different in length and first and second peripheral parts sandwiched by said two sides, setting first and second electrodes to each of said first and second peripheral parts, forming a first ditch going into said resistive film region from the shorter one of said sides to adjust the value of resistance between said two electrodes, and forming a second ditch extending into said resistive film region from the longer side facing said shorter side to readjust the value of resistance between said two electrodes.

4. A method of making a film resistor comprising the steps of preparing a support substrate having an insulating principal surface, forming a trapezoidal resistive film region on said principal surface, setting first and second electrodes on the two sides opposing in unparallel relation, and forming a ditch into said resistive film region from at least one of the two parallelly opposing sides of said resistive film region thereby to adjust the value of the inter-electrode resistance.

5. A method according to Claim 4, wherein said inter-electrode resistance is readjusted by forming a second ditch into said resistive film region from the longer one of the two parallel sides after said inter-electrode resistance is roughly adjusted by forming a first ditch into said resistive film region from the shorter side opposing said longer side.

6. A method according to claim 5, wherein the angle between the edge of said resistive film extending from said shorter side to said longer side and an edge of said film adjacent to said shorter side lies in the range of about 110° to 160°.

7. A method of making a film resistor comprising the steps of:

preparing a support substrate having an insulating principal surface;

forming a resistive film region on said principal surface having a first set of two parallel sides;

setting first and second electrodes on the two sides opposing in parallel relationship; and

forming a ditch into said resistive film region from at least one of two additional parallel opposing sides of said resistive film region which are inclined with respect to said first set of parallel sides,

whereby the value of the inter-electrode resistance is adjusted.

8. A method according to claim 7, wherein said resistive region includes an area of low resistivity disposed between said first set of two inclined parallel sides.

* * * * *