SLIDING-TYPE VARIABLE RESISTOR HAVING THIN FILM RESISTOR LAYER COMPRISING STRAP RESISTORS

1 Claim, 6 Drawing Figs.

ABSTRACT: The sliding-type variable resistor including thin film strap resistor layers formed by vacuum deposition, spattering, etc., upon an insulating material base, a plurality of tap electrodes and a sliding brush slideable thereover. Tap electrodes are arranged in the path of travel of the brush and extended in one direction from the path. Strap resistors are arranged with the same pitch as that of the tap electrodes and one end of the resistor overlays on the extended portion of the corresponding tap electrode. Each strap resistor overlays on the ends of two strap connectors, and each strap connector overlays on two adjacent strap resistors.
FIG. 2

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This invention relates to a variable resistor and more particular to thin film resistor layers and electrodes of the variable resistor.

An object of the present invention is to provide a variable resistor having thin resistor layers in which the stepped resistor layer section is provided so that the high resistance which has been so far unattainable by the conventional variable resistor can be obtained. The error caused by the misalignment of the mask patterns used in the vacuum deposition of the resistor layers, etc., may be minimized.

To this stepped resistor layer section is further connected a zigzag resistor section, so that one resistor layer may cover a wide range of resistance up to a very high resistance.

In brief, according to the present invention, a pattern is employed which permits one resistor layer to cover a wide range of resistance in the direction perpendicular to the path of travel of a sliding brush of an adjustable resistor. Furthermore, it is possible to minimize the error in resistance caused by the misalignment of the mask for forming tap electrodes with the mask for forming resistor layer and by the tolerances of the manufacture of the patterns. Therefore, an adjustable resistor with a higher degree of precision which can vary its resistance in accordance with a given function may be provided at a less expense with a high yield.

The objects, advantages and features of this invention will be described in detail referring to accompanying drawings, in which:

FIG. 1 is a plan view of thin film resistor layers of a conventional sliding-type variable resistor;

FIG. 2 is a plan view of one embodiment of the present invention;

FIG. 3 is for explanation of the correction is resistance in a step manner in accordance with the present invention;

FIGS. 4 and 5 are fragmentary plan views of the conventional resistors for explanation of the defects thereof, and

FIG. 6 is a view similar to FIG. 3 for explanation of the correction in resistance in a step manner in accordance with the present invention.

As shown in FIG. 1, in the conventional electrode and resistor layers formed through the masks by vacuum deposition, spattering, etc., the tap electrodes 1 are formed at right angles relative to the path of the sliding brush and a wedge-shaped resistor layer which is tapered in a certain manner is overlaid upon the tap electrodes 1. Another resistor layer 2 is located so as to extend from the tip end of the wedge-shaped resistor layer 2. The tip end of the resistor layer 2 has the width as minimum as possible in the fabrication technique and the resistor layer 3 has a resistance per unit of area (surface resistance) higher than that of the resistor layer 2. When a range of resistance is widened in one resistor layer as described above; the base width S of the resistor layer must be increased, but is limited in practice. Therefore, a number of deposition operations must be increased disregarding the increase in cost.

There has been proposed another method in which as shown in FIG. 4 the zigzag resistor members are connected in series with the wedge-shaped resistor layers. However, when the pitch of the tap electrodes is limited, there is a defect that the relative error is increased because of the distortion of the pattern as shown in FIG. 5.

The present invention contemplates to eliminate the defects of the conventional adjustable resistor of the type described.

In FIG. 2, reference numerals 4, 4' and 4'' designate tap electrodes which contact with a sliding brush and are made of a material having a low heat resistance, a strong resistance to abrasive wear and a property for ensuring a better electrical contact with the sliding brush. Reference numerals 5 and 5' designate connecting straps made of same material as the electrodes and formed by the vacuum deposition simultaneously with the formation of the tap electrodes 4, 4' and 4'' by use of the same mask. That is, the same or common mask is provided with slots for forming the tape electrodes 4, 4' and 4'' and the slots for forming the connecting straps 5 and 5'. A resistance layer 6 has a relatively high sheet resistance and a wedge shape generally indicated by P whose width S' is so varied as to provide a variation in resistance in accordance with a given function. (Such a resistor will be referred to as "function resistor" hereinafter for brevity.) Strap resistors 7 are formed simultaneously with the resistor layer 6 and arranged in side-by-side relation with the tap electrodes 4' with the same pitch therewith. The tap electrodes 4'' and the strap resistors 7 are overlapped at the outside of the path K of the sliding brush, and the width of the tap electrode 4'' is made wider than that of the corresponding strap resistor 7. The strap resistors 7' are also formed simultaneously with the resistor layer 6 and the strap resistor 7 and arranged so that two strap resistors 7' are provided for every one of the tap electrodes 4''.

The strap connectors 5 are overlaid with two strap resistors respectively in the stepped resistor section Q and one of the strap connectors 5 is connected to the strap resistor formed adjacent to the lower resistor layer. The strap connectors 5' are overlaid with all of the strap resistors 7' in the zigzag resistor section R. That is, the adjacent strap resistors which are not connected to a common tap electrode 4'' are bridged by the strap connector 5'.

Reference numeral 9 designates an electrically insulating base and is provided with a notch 10a at one portion of the outer periphery thereof at the intermediate of the zigzag resistor section S so that the strap resistors in the zigzag resistor section, the tap electrodes and the strap connectors are not overlapped one upon another when vacuum deposited. Reference numeral 10 is a pin which serves to determine the reference position in case of the vacuum deposition, of the resistance layers, and tap electrodes upon the base 9, by abutting the pin 10 against one side edge of the notch 10a of the base 9.

The sliding brush generally indicated by J is comprised of contacts J1, J2, J3 and J4 and adapted to slide over the path K. It is noted that the contacts are not arranged in line as shown in FIG. 2 so that the contactor as a whole may contact with more than two tap electrodes.

Next the mode of operation will be described. Assume that the wedge-shaped resistor layer 6 increases its resistance in a logarithmic manner. In this case, the width S' of the resistor is gradually decreased and reaches the limit of fabrication or deposition. In this case, the resistance is a function the distance from the terminal N, which is considered as the reference point, but in inverse proportion to the width. Therefore, when the width of each resistor is made constant and the resistors are arranged and connected as shown in the sections Q and R in FIG. 2, it is possible to obtain a higher resistance than the wedge-shaped resistor within a limited space. The step resistor section Q is interposed between the wedge-shaped resistor 6 and the zigzag resistor section R so that the abnormal resistance caused, as shown at the b and g in FIG. 5, by the misaligned positions between the tap electrode 4' and the strap resistor 7' and between the strap connector 5' and the strap resistor 7', can be prevented. That is, as shown in FIG. 5, in the zigzag resistor section R, two strap resistors 7' are connected to one tap electrode 4'' in spaced-apart relation by a distance i, and the tolerance ε between the strap connector 5' and the strap resistor 7' and the tolerance ε between the tap 4'' and the strap resistor 7' must be provided within a limited space and pitch, so that these tolerances cannot be made larger. Furthermore, the width f of the strap connector 5' cannot be made larger because of the spacing therewith in the vacuum deposition step, the position of the base 9 is determined by fitting the reference pin 10 into the notch 10a, but as long as the taps 4'', the strap connector 5' and the strap resistor 7' are deposited individually, the errors in their relative positions are inevitably caused. Therefore, as shown in FIG. 5, the deviations are caused between the tap 4'' and the
Regarding (n-1) tap, the strap connector Sa'' is placed between the electrode 4a' and the strap connector Sa so that the distance Yn is reduced by the width W, so that the distance Zn should also be reduced by W for securing Yn, namely,
\[ Zn = 2(W+S)Zn \geq W \quad (4) \]

In order to prevent the overlapping between the adjacent strap connectors Sa'' and Sa and provide a spacing larger than S in the direction of the strap resistor in view of the tolerance required in the preparation of the mask for vacuum deposition, the value of y is
\[ y \geq 2(W+S) \quad (5) \]

In order that the strap connector Sa'' may be spaced apart from the lower end 4b' of the tap 4a' by a distance more than 4'
\[ Yn' = S \]

That is, from equation (3),
\[ Yn' + W \geq y \quad (6) \]

Therefore, from equations (5) and (6),
\[ Yn + W \geq y \geq 2(W+S) \quad (6') \]
\[ Yn \geq 2S + W \quad (6) \]

In order that the connector Sa'' may be spaced apart from the tap (n-1) by a distance longer than S,
\[ Yn + 1 + W - S \geq y \quad (7) \]

From equations (5) and (7),
\[ Yn + W - S \geq y \geq 2(W+S) \quad (8) \]

Hence, when the equations (4), (5), (6') and (8) are satisfied, the strap connector may be repeated as many as times required so that the steplike resistor may be arranged effectively in a limited space so that a wide and stable resistance range may be provided.

In order to provide a sufficient spacing in Fig. 4, the strap connectors may be arranged slantingly as indicated by dotted lines 11 and 12 in Fig. 2.

From the foregoing, it is seen that one resistor layer may provide a wide range of resistance with less relative error in a limited space. Even though the arrangement is such that the two adjacent tap electrodes are interconnected by the strap resistor layer extending radially, the influence by the misalignment between the tap electrode and the strap resistor may be remarkably minimized. Therefore, the adjustable resistor whose resistance may be varied in accordance with a given function may be provided at a low cost with a higher degree of accuracy.

From the construction of the present invention, the following advantages may be accrued:

1. In the step resistor section, the lengths of the strap resistors may be reduced in the lower resistance side so that the errors in width of the strap resistors may be reduced. Therefore, the relative error in resistance in the lower resistance side may be minimized.
2. The spacing between the strap connectors, that is the dimensions of the bridging portion of the mask may be sufficiently provided without causing any difficulty in fabrication. Furthermore, the pitch can be made smaller.
3. More space in the mask may be utilized and a life thereof may be increased. The mask alignment tolerance may be increased.
4. The types of the resistor layers may be reduced so that a number of vacuum deposition may be reduced, thereby preventing the superposition of various errors in vacuum deposition. Thus better quality and low-cost precision resistors may be provided.

What we claim is:

1. A variable resistor comprising thin film resistor layers formed upon an insulating base, a plurality of tap electrodes and a sliding brush for slidable movement over said tap electrodes, an improvement resides in that strap-shaped tap elec-
trodes (4') arranged in side-by-side relation in the path of travel of said sliding brush are extended in one direction out of said path;

strap resistors (7) arranged side-by-side relation with the same pitch with that of said tap electrodes and in the one-to-one relation therewith have their one ends overlaid upon said extended portions of said tap electrodes respectively, the width of each of said strap resistors being smaller than that of each of said tap electrodes;

the sheet resistance of each of said strap resistors is higher than that of each of said tap electrodes each of said strap resistors is overlaid with ends of two strap connectors (5), one of said two straps being connected to the adjacent strap resistor on the lower resistance side while the other, to the adjacent strap resistor on the higher resistance side; and each of said strap connectors is overlaid only upon the two adjacent strap resistors.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION


Inventor(s) TATSUO FUJII ET AL

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 61, change "(n-" to -- (n-2) --. Column 4, line 3, change "Y_n1\text{11}" to -- Y_{n-1} --; line 4, change "Z_n1\text{11}" to -- Z_{n-1} --; same line, change "Y_n1\text{11}" to -- Y_{n-1} --; line 6, change "Z_n1\text{11}" to -- Z_{n-1} --; line 10, change "Z_n1\text{11}" to -- Z_{n-1} --.

Signed and sealed this 9th day of May 1972.

(SEAL)
Attest:

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Attesting Officer Commissioner of Patents