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[33] **Japan**
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[54] METHOD OF MANUFACTURING THIN FILM RESISTOR ELEMENTS

3 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **29/620,** 29/621, 338/195
[51] **Int. Cl.** **H01c 7/00,** H01c 17/00
[50] **Field of Search** 29/620, 621, 580, 593, 583; 338/195

[56] **References Cited**

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ABSTRACT: Described is a method of manufacturing thin film resistor elements. The method is characterized in that intermediate layers consisting of a metal having a temperature coefficient different from the temperature coefficient of a resistor film and capable of preventing diffusion of the soldering material and readily solderable terminal metal layers are provided on terminal parts of the resistor film and the temperature coefficient of resistance is minutely adjusted by removing parts of said intermediate layers.

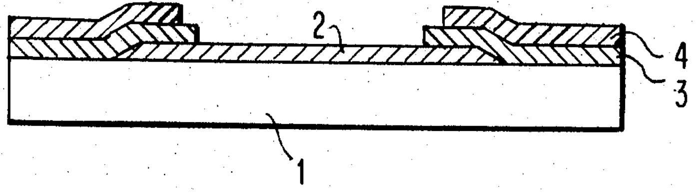
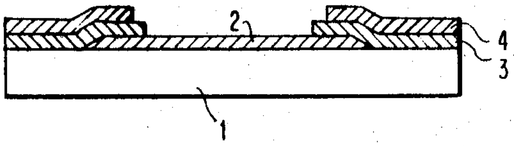


Fig. 1



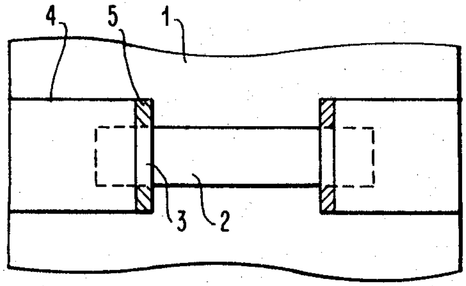


Fig. 2

METHOD OF MANUFACTURING THIN FILM RESISTOR ELEMENTS

This invention relates to a method of manufacturing thin film resistor elements capable of obtaining the desired temperature coefficient of resistance and more particularly to a method of minutely adjusting the temperature coefficient of resistance of a resistor element in a thin film circuitry.

According to the increasing precision of communication apparatuses, electronic parts used therein are required to have high precision and resistor elements are required to have temperature coefficient of resistance of under 10 p.p.m./° C. Moreover, in a thin film circuitry, it is often required to set the resistance value within the range of the regulated value and limit the differences between temperature coefficients of resistance of a number of resistor elements adjacent to each other within several p.p.m./° C. Resistance value has heretofore been adjusted fundamentally by cutting away a part of the resistor, but no effective method of simultaneously minutely adjusting the temperature coefficient of resistance has been found. It is therefore an object of this invention to provide means or method for minutely adjusting the temperature coefficient of resistance as well as simultaneously adjusting resistance value.

The invention will be described in detail with reference to the accompanying drawings, in which FIG. **1** is a sectional view of a resistor element of this invention and FIG. **2** is a plan view of said resistor element.

In the two drawings, a resistor film **2** is formed on a substrate **1** consisting of a glazed ceramic by vacuum deposition or cathode sputtering and further intermediate layers **3** and terminal metal layers **4** are formed on the two ends of film **2**. Intermediate layers **3** operate to increase the mechanical adhesive strength of terminal metal layers **4** and prevent diffusion of soldering materials for attaching connecting leads or outer leads. According to this invention, these intermediate layers **3**, by being provided as shown in the drawings, further facilitate adjustment of the temperature coefficient of resistance. Intermediate layers **3** consist of a metal having a temperature coefficient different from the temperature coefficient of resistance film **2** and are overlapped on the two ends of resistor film **2** as shown. It is important in this invention that the intermediate layers are provided so that they may substantially form parallel resistances by being combined with parts of the resistor film and that the parts of the intermediate layers operating as the parallel resistors and on which terminal metal layers **4** are not partially overlapped are exposed. Terminal metal layers **4** consist of a solderable metal of a low sheet resistivity value.

When resistance of the part of resistor film **2** between the ends of intermediate layers **3** is R_1, resistance of the exposed part of an intermediate layer is $R_2$and resistance of the part of the resistor film under said intermediate layer is R_1' in the resistor element of a structure as shown in FIGS. **1** and **2**, the equivalent circuit can be formed by connecting R_1' and R_2 in parallel to one another and connecting R_1 in series to R_1' and R_2. Ordinarily, R_1' is related with R_2 as $R_1' \gg R_2$ and a resistor film of a small temperature coefficient is selected and therefore said equivalent circuit can be dealt with as a series circuit of R_1 and R_2. Therefore, when temperature coefficients of R_1 and R_2 are α_1 and α_2 respectively, temperature coefficient α of said resistor element can be expressed as

$$\alpha = \frac{\alpha_1 + (\alpha_2 \cdot R_2/R_1)}{1 + \frac{R_2}{R_1}}$$

and since R_1' is related with R_2 as R_1' as $R_1 \gg R_2$, α can be expressed as

$$\alpha = \alpha_1 + \alpha_2 \cdot R_2/R_1$$

It is evident from this formula that the temperature coefficient of the resistance element depends on R_1 and R_2. If R_1, i.e. the length of the resistor film, is made large, the temperature coefficient will vary as evident from the above formula but here, according to this invention, the part of the intermediate layer that is not overlapped on the resistor film and is exposed is removed physically or chemically or increase R_2. In other words, R_2 is increased in accordance with the increase of R_1 so that R_2/R_1 may be at a constant value and thus minute adjustment of the temperature coefficient of resistance became possible.

An embodiment of this invention will be now described in detail. As shown in the drawing, the substrate was kept at a temperature of 350° C. and resistor film **2** of Ni-Cr (80 percent–20 percent) was deposited to a thickness of 400A and intermediate layers **3** of chromium were deposited to a thickness of 1000A and further terminal metal layers **4** of palladium were deposited to a thickness of 5000 A. Here, said chromium layers have a resistivity of about 20 $\mu\Omega$ cm. and a temperature coefficient of resistance of 1700 p.p.m./°C. Assuming that the entire surfaces of the palladium terminals are soldered, the temperature coefficient of resistance α, as described above, can be expressed as follows ignoring the resistance of palladium:

$$\alpha = \alpha_1 + \alpha_2 \cdot R_2/R_1$$

Assuming now that the length of the exposed part of a chromium in the lengthwise direction is 0.25 mm. and the width is 1.2 mm. in FIG. **2**, resistance R_2 of the exposed part becomes 0.83 [Ω]. When R_1 is **300** [Ω], temperature coefficient of resistance α_{300} will become

$$\alpha_{300} = \alpha_1 + 1700 \times (0.83/300) = 4.7 [\text{p.p.m./°C.}]$$

and when R_1 is 3000 [Ω] under the same pattern, temperature coefficient of resistor α_{3000} will become

$$\alpha_{3000} = \alpha_1 + 1700 \times (0.83/3000) \alpha_1 + 0.47 [\text{p.p.m./°C.}]$$

This means that the difference between the temperature coefficients at terminals is about 4 [p.p.m.°C.]. However, if the length of the exposed part is made 0.25 mm. and discharge trimming is performed according to this invention until the width of said exposed part becomes 0.3 mm., i.e., equal to the width of the resistor film of nickel chromium and parts **5** shown by oblique lines of the intermediate layers of chromium of FIG. **2** are removed, R_2 becomes 3.33 [Ω] and when R_1 is 3 KΩ, α'_{3k} becomes $\alpha'_{3k} = \alpha_1 + 1700\ (3.33/3000) = \alpha_1 + 1.88$[p.p.m./°C.b' and the difference between the temperature coefficients at terminals can be made as small as 2.82 [p.p.m./°C.].

We claim:

1. A method of manufacturing thin film resistor elements which comprises providing, on a substrate base, a resistor film, intermediate metal layers, and readily solderable terminal layers, said intermediate layers having a temperature coefficient different from that of said resistor film and capable of preventing diffusion of soldering material, said readily solderable terminal layers being provided on terminal parts of said resistor film and minutely adjusting the temperature coefficient of resistance by removing parts of said intermediate layers.

2. The method of claim **1**, wherein the intermediate layers, consisting of a metal having a temperature coefficient different from the temperature coefficient of a resistor film and capable of preventing diffusion of the soldering material, are overlapped and widely coated on terminal parts of the resistor film; readily solderable terminal metal layers are provided on said intermediate layers so that parts of said intermediate layers that are not overlapped on said resistor film may be exposed and the temperature coefficient of the resistor element is minutely adjusted by removing parts of said exposed intermediate layers.

3. The method of manufacturing thin film resistor elements of claim **2**, wherein nickel-chromium is used as the resistor film and chromium is used as the intermediate layers.