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(54) THIN FILM RESISTOR AND METHOD FOR MAKING THE SAME

(71) We, ASAHI KASEI KOGYO KABUSHIKI KAISHA, a corporation organised under the laws of Japan of 2—6 Dojima-hama, 1-chome, Kita-ku, Osaka, Japan, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a thin film resistor and a method for manufacturing the same, and more particularly to a thin film resistor which can be integrally built in a substrate such as a circuit board or ceramic and a method for manufacturing the same.

The thin film resistor has been recently used in wide applications such as a thin film hybrid integrated circuit (hereinafter referred to as a hybrid IC) and a thermal head, and hence it has been strongly desired to obtain the high quality and high reliability thin film resistor having a fine pattern and simplify the manufacturing method therefor.

In manufacturing a printed wiring circuit having resistors, the resistors as the discrete components have been packaged on a printed circuit board one by one by soldering the lead wires of the respective resistors. This process, however, requires a very high packaging cost and the quality of the resulting product was far inferior to that required for use in a micro-circuit. In the well-known process, the reduction of the packaging volume has already been limited.

Another type of thin film resistor having a microcircuit structure which is available to manufacture a thin film hybrid integrated circuit has been manufactured by one of the following two methods. One is called a pattern deposition method, in which thin film resistor material is vapor deposited on a substrate in a desired pattern through a mask. The other method is called a photoetching method in which thin film resistor material adhered on a substrate is coated with photo-sensitive resin (or photo-resist) which is then exposed to light through a desired pattern mask. Then, the resin coating is rinsed and selectively removed to thereby obtain the desired pattern, and etching is carried out through the mask to remove undesired portions of the resistor material on the substrate while leaving the desired pattern of the resistor. The photo-resist method is disclosed, for example, in the U. S. Patent 3,977,840.

Those methods, however, require very complex steps to provide a desired resistance and include a problem of mask misalignment by radiated heat from an evaporation source for pattern deposition and hence require precise control. The resistor formed by such methods is trimmed by laser trimming or sand-blasting, such as the laser-trimmed film resistor shown in the U. S. Patent 3,947,801. Consequently, the manufacturing cost is high. Furthermore, since the photoetching method is used, a troublesome wet process is unavoidable. Thus, a highly reliable microcircuit thin film resistor has been desired.

As the prior art to the present invention, there is the U. S. Patent 3,614,423 relating to pattern evaporation technique although it does not relate to the manufacturing technique of the resistor. The U. S. Patent 3,136,680 discloses bonding material for polytetrafluorethylene copper laminate as a circuit board from which conductive patterns are formed by etching.

The present invention has been made in view of the requirement of overcoming the difficulties described above for the hybrid IC or the printed circuit board.

According to the present invention there is provided a method for manufacturing a thin film resistor comprising the steps of:

depositing a continuous thin film resistor material layer on at least one main side surface of a dielectric substrate; and

selectively irradiating said thin film resistor material through a mask with high intensity light having an energy above a critical value at which said resistor material is dispersed at irradiated portions thereof to form a desired pattern of resistors in the remaining non-irradiated portions of said resistor material layer.

The invention also provides thin film resistors produced by this method and hybrid intergrated circuits and printed circuit boards comprising such film resistors.

These and other features and advantages of the present invention will be apparent from the following description of the preferred embodiments of the invention when taken in conjunction with the accompanying drawings, in which:

Fig. 1 shows a cross sectional view of a thin film resistor illustrating one embodiment of the present invention;

Figs. 2A and 2B show process chart for illustrating a method for manufacturing the resistor shown in Fig. 1;

Fig. 3 shows a sectional view illustrating an embodiment of a circuit board which incorporates the resistor of the present invention;

Fig. 4 shows a sectional view of another embodiment of the circuit board which incorporates the resistor of the present invention;

Figs 5A to 5E show process chart for illustrating another embodiment of incorporating the thin film resistor of the present invention in a circuit board; and

Figs. 6A to 6C show process chart for illustrating another embodiment of the manufacturing method of the thin film resistor of the present invention.

Fig. 1 shows a cross sectional view of a basic structure of a thin film resistor of the present invention, in which a thin film layer 2 of resistive material is deposited on a dielectric substrate 1 in a desired pattern. The substrate 1 may be made of any material which allows the deposition of the thin film resistor material, and it may be, for example, ceramic substrate such as alumina substrate, glass substrate, monocrystalline sapphire substrate or resin substrate, which are used for thin film hybrid IC's. Of those substrate materials, the resin substrate is particularly advantageous over the other substrates in that it has a lower threshold energy for dispersion required to form the resistor pattern to be described later and a large size substrate (circuit board) is available. Preferable resin substrate materials are polyimide, polyamide, epoxy resin, polyester, polyethylene, polystyrene, polyparabanic acid and phenolic resin. The printed circuit board laminate using any of those materials is advantageously used as the substrate 1.

Referring to process chart of Figs. 2A and 2B, the manufacturing method of the thin film resistor shown in Fig. 1 is explained. In forming the patterned thin film resistor layer 2, resistive material 22 having an energy radiation responsive dispersing property by absorbing the radiated energy is deposited on the entire surface of one side of the substrate 1, to a predetermined thickness, as shown in Fig. 2A. A mask 6 made of stainless steel or nickel or chromium is applied as shown in Fig. 2B and high intensity light is irradiated in the direction shown by arrows from a source (not shown) such as a xenon discharge lamp or a YALG laser. When the deposited resistive material 22 receives radiated energy above a predetermined threshold or a certain critical value, the portions 7 of the resistive material 22 which have been radiated are dispersed and removed from the surface of the substrate 1. As a result, non-radiated portions 2 of the resistive material remain unremoved to form a pattern of the resistor. The resistivity of the coated substrate surface at those portions in which the resistive material 22 dispersed by the energy radiation is substantially equal to the resistivity of the base substrate and the surface resistance is in the order of 10^{12} ohms.

This method is referred to as a dry process pattern formation method by energy radiation and dispersion. The term "dispersion" herein used is intended to include the following phenomenon. When the thin film resistor material deposited on the dielectric substrate receives the radiated energy, it may absorb the energy and melt to form fine particles by surface tension creating a discrete condition. In another case, when the thin film resistive material receives the energy radiation, it may absorb the energy and break itself into fine fragments by an instantaneous thermal stress, also creating a discrete condition. In either case, the fine particles or fine fragments of their radiated resistive material may be removed from the surface of the substrate by scattering or portions of them may remain on the surface of the substrate. The characteristic feature of dispersion is the change from a continuous condition to the discrete condition of the fine particles or fragments. The dispersion state of the resistive material can be determined by examining whether the continuity of the thin film has been lost or not, by a microscope observation or light transmission method. The thin film material showing the above phenomena is said to have the dispersion property. The thin film pattern formation method using the above dispersion property is called the energy radiation responsive dispersion method. Dispersion imaging is described in general in U. S. Patent No. 4,000,334.

The threshold (i.e. the critical value) of the energy herein used is defined as a minimum energy required to disperse the thin film resistor material. The magnitude thereof may be represented by an energy radiated to a unit area of the radiated body. Usually, the amount of energy is expressed by an electric power which is proportional to an input to the energy radiation apparatus, and the threshold of the energy may be simply expressed by the magnitude of the electric power.

As the input power to the energy radiation apparatus which radiates the energy to the thin film resistor material is gradually increased from a low level, the thin film resistor material starts to disperse when a predetermined power level is reached, and the continuity of the thin film is lost. As the power is further increased, the radiated portions of the thin film resistor material completely disperse.

The energy threshold is defined here by the input power at which the deposited thin film resistor material starts to disperse to loose the continuity of the thin film. The energy threshold or energy critical value may be expressed by the input power or by the radiation energy per unit area. As will be described later, when the high intensity light radiation apparatus used was a xenon discharge lamp of the type "FX—77 C—8" manufactured by EG & G Corp, of U. S. A., the threshold required to disperse the Ni-Cr alloy thin film resistor material vapor deposited on the epoxy resin laminate was measured as 1200 W input power.

The thin film resistor material used in the present invention may be any material which acts as an electrical resistor and has an energy radiation responsive dispersion property. Preferable resistive materials are Ni, Ru, Pt, Pd, W, Mo, Ta, a ruthenium oxide, a tantalum oxide, and alloys of Ni-Cr, Co-P, Ni-B, Ni-P, Ni-Ce, Cr-P, Ce-P, Cr-B. Of those materials, Ni, Ru, Pt, Pd, Ni-Cr alloy and ruthenium oxide are particularly preferable.

The resistive material is deposited on the surface of the substrate as shown in Fig. 2A by a well known method such as vapor deposition, sputtering or ion-plating and other similar methods. The thickness of the resistive material depends on the particular material used but the preferable range thereof is 50Å to 3 μ, and more preferably 100 Å to 1 μ.

Fig. 3 shows an embodiment of the present invention embodied in a printed circuit board, in which a pattern of thin film resistors 2 and a pattern of wiring conductors (lands) 3 are formed on the dielectric substrate 1 which is the printed circuit board. The resistors 2 and the conductor lands have overlapped plate structures which are directly connected together during the manufacturing process so that no soldering i.e., no solder-bonding is required to connect the resistors 2. In Fig. 3, the conductor lands 3 are previously formed on the substrate 1 and then the thin film resistors 2 are deposited. Instead, depending on the design, a desired pattern of the thin film resistor 2 may be formed initially, then the printed wiring conductors 3 may be formed by for example electroless plating such that portions thereof partially overlaps with the resistors 2 to directly connect them together in a solder-free overlay structure.

Fig. 4 shows a sectional view of a circuit board in accordance with another embodiment which has patterned thin film resistors 2 formed on one principal surface of the dielectric substrate 1. As shown in Fig. 4, the circuit board has the thin film resistors 2, on one principal surface (side) thereof, formed by the dry process pattern formation by using the dispersion property of the resistive material and conductor lands 3 formed on the other principal surface (side) of the substrate, and the lands on both sides of the substrate are interconnected by through-holes having conductive layers formed on inner walls of the holes extending through the substrate. Although not shown, in the circuit board having through-holes for electrically interconnecting both sides of the board, the packaging density of electronic components can be increased when the thin film resistors 2 and the conductor lands 3 are integrally formed on both sides of the board.

In the circuit board which advantageously incorporates the present invention, the conductor material for a circuit pattern of a conductive base (land) may be metal or alloy which is conventionally used as a conductor.

Preferable material is a known metal such as Al, Au, Cu, Pt, Pd, Pb, Sn, Fe, Zn, In, Ni, Cr, Ag, Bi or Ti, or an alloy thereof. The material may be used in any form as required and preferably it is deposited on the substrate in the form of thin film or foil. The conductor lands may be formed by a well known conductor formation method which is conventionally used to form the thin film or a well known method used in the manufacture of a printed circuit board.

Preferable methods for forming the conductor lands are a method of etching the thin film or foil conductor formed on the substrate to form a pattern of the conductor, a method of vapor depositing conductor in a pattern, a method of sputtering in a pattern, a method or wiring wires and a method of plating conductor in a pattern.

In a more preferable method, metal or alloy thin film conductor material layer having the dispersion property by absorption of the radiated energy is formed on the substrate, and then the high intensity light is applied through a mask made of stainless steel or chromium to make a pattern of circuit of the conductor thin film layer to form the conductor lands. Consequently, the formation of the conductor lands does not need photoetching process.

Referring to Figs. 5A to 5E, a method of the present invention for forming the thin film resistors and the conductor lands on a hybrid circuit board is explained.

As shown in Fig. 5A, the thin film resistor material layer 22 is first formed on the circuit board 1, and a hard mask is settled on the resistor material layer closely or at a suitable distance depending on the manufacturing conditions to define resistor regions of a combined pattern (Fig. 5D) of a desired resistor pattern and a desired conductor land pattern. Then, an energy above the threshold to the deposited resistor is radiated thereto by the energy radiation apparatus such as that described above to form the combined pattern of the resistor 2 as shown in Fig. 5B. Then, applying a mask 9 of a coating using plating resist, conductive metal material is plated to only the conductor land pattern on the resistive material layer 2 left on the substrate. As a result, the conductor lands 5 as shown in Fig. 5 are deposited on the thin film resistive material layer 22. The areas 2 in which the conductive metal is not plated act as resistors.

In forming the conductor lands on the thin film resistors, the resistive material is preferably Ni, Pt, Cr, Ru, Ta or alloy thereof. The plating resist used may be photosensitive epoxy resin, whose coating has an advantage in that it need not be removed after plating process but may be used as a part of the circuit board as well as a protective layer for protecting the formed resistors from their environments.

In Fig. 4, when the circuit board of the present invention having through-holes is manufactured using double-sided or single-sided copper bonded laminate, the through-holes may be formed by copper plating which is conventionally practiced in manufacturing the printed circuit board. When a ceramic substrate is used as the substrate, a method which is conventionally used in the manufacture of the hybrid IC may be used. The drilling process may be carried out either before or after the dry process pattern formation of the present invention. The inner walls of the holes may be plated simultaneously with the plating process of the conductor lands.

Referring to Figs. 6A to 6C, another embodiment of the manufacturing method of the present invention is explained. In the present embodiment, a polymer layer 8 is used as an underlying layer i.e., a prime layer of the resistive layer in order to enhance the ability of the resistive pattern formation by the energy radiation responsive dispersion method described above. That is, the sensitivity of the pattern formation is raised to decrease the threshold of the radiation energy.

The polymer layer 8 such as epoxy resin bond is applied on the surface of the substrate 1 (Fig. 6A). The thin film resistor material layer 22 is then deposited on the polymer layer 8 (Fig. 6B). Then, a radiation energy 10 such as flash light of a xenon discharge lamp or a laser beam is radiated to the surface of the substrate of Fig. 6B through a mask 6 of chromium thin film formed on a glass substrate or a hard mask made of a thin metal plate such as stainless steel having apertures formed in a desired pattern (Fig. 6C). The polymer layer 8 is not influenced by the energy radiation.

As compared to the present embodiment, in forming the pattern of the thin film resistor, the prior art photoetching method must include the steps of resist application, drying, exposing, developing, rinsing, drying and etching. In the present method, on the other hand, only the exposing step is required to form the desired thin film resistor. Accordingly, to compare with the complex steps of the prior art method, the present method can materially reduce the number of steps required and hence simplifies the process. The manufacturing facilities required are only the exposing apparatus. Further, since no experience and skill is required to carry out the process, a very precise resistor can be manufactured. Accordingly, the present invention can be applied to various applications which require minute resistor structures or miniature resistors such as the formation of the thin film resistor circuit on a printed circuit board or ceramic die or the resistor of a thermal head.

The circuit board having the thin film resistors of the present invention allows the formation of the pattern of fine resistors and also allows the formation of high precision resistor. Unlike the prior art method, the present method is free from the problem of aging due to the remaining etchant or the need of trimming. Furthermore, the resistor of the present invention allows high packaging density and a high reliability because of simple manufacturing process.

Examples of the manufacturing method of the present invention are described hereinafter, although it should be understood that the present invention is not limited to the particular examples.

Example 1

A resist was screen-printed on a copper bonded laminate made of glass fiber reinforced phenol-epoxy resin, and the copper was etched by a ferric chloride basic etching solution to manufacture a printed circuit board having conductor lands and twelve resistor terminals. After the etching resist had been removed, Ni-Cr alloy thin film was vapor deposited on the entire surface of the printed circuit board thus formed, to the thickness of 500 Å. Then, intense flash light having the duration of 100 μ seconds was in a single-shot fashion radiated from a 1300 watts xenon discharge lamp using an optical system to the conductor patterns and the portions between respective pairs of the twelve terminals, through a chromium mask having a resistor pattern, under a room temperature and an atmospheric pressure to disperse the Ni-Cr alloy thin film at the radiated portions. In this manner, the Ni-Cr alloy thin film alloy portions other than the resistor pattern portions were removed to form six resistors, that is, one 200 KΩ resistor, two 1.5 KΩ resistor, one 3 KΩ resistor, one 5 KΩ resistor and one 10 KΩ resistor, on the circuit board between respective pairs of the twelve terminals. The resistances of the resistors were measured and the precision was determined to be not more than ±3%. The flash light was radiated by the arrangement shown in Fig. 2B and the chromium mask was used as the mask 6.

After the conductor lands and the resistors had been formed on the substrate 1, phenol-epoxy resin bond, "XA—564—4" prepared by Bostik Japan Co. was applied to the thickness of 5μ except on those terminals which were to be connected externally of the printed circuit board, and the resin bond was then thermally treated at 160°C for one hour to harden it to form protective layer. The substrate 1 having the protective layer was then dipped in a soldering bath at 200°C to deposit Pb-Sn solder having a melting point of 183°C on the exposed terminals. In this manner, the printed circuit board having the thin film resistors was manufactured.

In forming the resistors on the printed circuit board, the present method can accomplish the formation of the resistors only by the vapor deposition and the radiation of the flash light in contrast to the prior art method in which the resistors are connected to the conductor lands by soldering. Therefore, the manufacturing process is simple and the packaging cost per resistor is reduced by the factor of approximately three. Furthermore, since the electrical connecting portions of the resistors do not include the soldered areas, there is no possibility of the break of the connecting portions.

Example 2

The present example used the method shown in Figs. 6A to 6C. The phenol-epoxy resin bond was applied to the thickness of 5 μ on a square alumina substrate having the length of one side of 5 cm and the thickness of 0.5 mm. Pt film was vapor deposited to the thickness of 300 Å on the entire surface of the bond. A high intensity of laser light from Nd·YALG (neodymium-yttrium - aluminum - garnet) laser having a pulse duration of 50 μ seconds and an output power of 50 millijoule per one pulse was radiated using an optical system through a chromium mask to form one hundred resistors each having the resistance of 5 KΩ±3.5% on the substrate in square areas each having the length of one side of 4.5 mm.

Copper leads of 0.08 mm in diameter were solder-bonded to opposite ends of the respective resistors, and the assembly was molded by phenol-epoxy of the thickness of 20 μ to manufacture a probe of a platinum resistance thermometer which utilizes the change of electrical resistance by temperature. In this manner, the fine resistor pattern having one hundred resistors in respective ones of 4.5 mm×4.5 mm square regions was prepared with high precision.

Example 3

In the present example, the present invention was applied to the manufacture of a hybrid IC.

Ni-Cr alloy resistive material was vapor deposited to the thickness of 500 Å on the entire surface of the ceramic substrate bearing the conductor lands. Intense flash light from the 1500 watts xenon discharge lamp having the duration of 100 μ seconds was radiated to the vapor deposited resistor material through a hard mask of stainless steel having a desired mask pattern. In this manner, two 100 Ω resistors, two 200 Ω resistors, two 1 KΩ resistors and two 2 KΩ resistors were formed between respective pairs of terminals on the circuit board, and a circuit having five 3 KΩ resistors was further formed. Then, a protective coating made of epoxy polymer was applied on the substrate except on the terminals to be connected externally, and the coating was thermally treated to fully harden the protective polymer layer. In this manner, the thin film circuit using the ceramic substrate was completed.

Example 4

In the present example, the substrate was pretreated before the resistive material had been deposited on the ceramic substrate of the Example 3 in order to enhance the ability of the formation of the resistor pattern by the energy radiation.

A circuit board having the conductor lands formed on the ceramic substrate to which phenol-epoxy had been applied to the thickness of 5 μ was prepared. Ni-Cr alloy resistive material was vapor deposited to the thickness of 500 Å on the entire surface of the substrate. A single-shot flash light from the xenon discharge lamp having the duration of 100 μ seconds was radiated to the substrate through a desired chromium mask to form three 100 Ω resistors, one 500 Ω resistor and one 2 KΩ resistor on the substrate. In the present example, because of the underlying phenol-epoxy layer, the threshold of the energy of the xenon discharge lamp flash light was so lowered that the dispersion by radiation occurred at the output power of 1100 watts to form the resistor pattern in accordance with the chromium mask pattern. Thereafter, the protective coating of epoxy polymer was applied on the surface of the substrate except on the connecting portions to the external, and the assembly was heat treated to fully harden the coating. In this manner, the thin film circuit using the ceramic substrate was completed.

Example 5

The present example shows the manufacture of the circuit board having the thin film resistors shown in Fig. 4.

Epoxy resin bond "XA—564—4" prepared by Bostik Japan Co. was coated on both sides of a polyimide film such that it had the thickness of 15 μ after having been dried, and then it was heated at 180°C for 30 minutes. Nickel was vapor deposited to the thickness of 1000 Å on one side of the polyimide film substrate and nickel-chromium was vapor deposited to the thickness of 1000 Å on the other side to form a blank circuit board. The blank circuit board was punched to form holes, and copper was vapor deposited obliquely to the thickness of 4000 Å to the holes of the substrate from the side of the nickel deposition of the polyimide film substrate.

A flash light from a 1500 watts xenon discharge lamp having the duration of 100 μ seconds was instantaneously radiated to the nickel conductor layer and the nickel-chromium resistor layer on the substrate through desired circuit pattern masks, respectively.

In this manner, two 5 KΩ resistors, five 10 KΩ resistors and one 80 KΩ resistor were formed on one side of the substrate. The nickel conductor circuit was formed on the other side to complete the intended circuit board. The variance or the precision of each of the resistances of the thin film resistors of the circuit board was within ±5%. The resistor pattern included a fine pattern of 20 lines/mm.

Example 6

The epoxy resin bond "XA—564—4" prepared by Bostik Japan Co. was applied on both sides of the glass fiber reinforced epoxy resin laminate to such thickness that it had the thickness of 25 μ after having been dried. The epoxy bond was heated at 180°C for 20 minutes. Copper was vapor deposited to the thickness of 100 Å on one side of the laminate and nickel was vapor deposited thereon to the thickness of 100 Å, and nickel-chromium was vapor deposited to the thickness of 3000 Å on the other side of the laminate to form a blank circuit board. Holes were drilled in the blank circuit board by a well-known numeric control system and the inner walls of the holes were activated by dropping activating solution consisting of tin chloride and palladium chloride in the holes. Thereafter, like in the case of the Example 5, a flash light from the xenon discharge lamp was radiated to both sides of the laminate through masks to form the copper conductor circuit pattern on one side of the laminate and the resistor pattern on the other side of the laminate. The epoxy resin bond "XA—564—4" was then applied to the resistor pattern side of the laminate to such thickness that it had the thickness of 10 μ after having been dried. Then the conductor patterns and the holes were electroless plated to the thickness of 5 μ using the electroless copper plating bath "Cp-70" prepared by Shipley Co. of U. S. A. It was then heat treated at 180°C for 60 minutes. In this manner, the circuit board having the resistors on one side which are connected to the conductive lands on the other side through the through-holes was completed.

Example 7

The present example used the method of Figs. 5A to 5E.

The epoxy resin bond "XA—564—4" was applied on the polyimide film to such thickness that it had the thickness of 10 μ after having been dried, and it was heat treated at 180°C for 20 minutes, and then nickel was vapor deposited thereon to the thickness of 1000 Å. Then, a flash light from the 1500 watts xenon discharge lamp having the duration of 100 μ seconds was radiated through a desired circuit pattern mask. Photosensitive epoxy resin composition consisting of 20 parts by weight of epoxy resin, "AER—661" prepared by Asahi Chemical Co. (bisphenol-A, epoxy equivalent 450—500), 2.06 parts by weight of reaction product of 1.73 parts by weight of 4 - aminomethyl - 1,8 - diaminoctane and 1.06 parts by weight of acrylonitrile, 6.22 parts by weight of carbontetrabromide and 40 parts by weight of chloroform, was applied to the patterned nickel layer to such thickness that it had the thickness of 5 μ after having been dried. It was then exposed to light from a 2 KW mercury lamp for two minutes through a desired circuit pattern mask. Thereafter, it was heated at 110°C for 20 minutes and then developed by aceton to wash away the areas corresponding to the conductor lands. The conductor lands were then electroless plated with copper to the thickness of 5 μ using the electroless copper plating bath "CP—70", and they were then heat treated at 180°C to form the circuit board having the fine pattern of resistors at 10 lines/mm and the conductor land pattern and copper plated conductor lands and non-plated nickel thin film layer resistors.

Example 8

Platinum was sputtered to the thickness of 300 Å on the polyimide film substrate. It was then exposed to a flash light from the 1500 watts xenon discharge lamp having the duration of 100 μ seconds to selectively disperse the platinum deposited on the substrate. Photosensitive epoxy resin composition consisting of 20 parts by weight of epoxy resin "AER—661", 1.9 parts by weight of diamino-diphenylmethane, 6.3 parts by weight of carbontetrabromide and 40 parts by weight of methyl ethyl ketone was applied to the patterned platinum layer to such thickness that it had the thickness of 5 μ after having been dried, and the epoxy resin composition was exposed to a light from the 2 KW mercury lamp for two minutes through a desired circuit pattern mask, and then it was heated at 130°C for 30 minutes and developed by aceton to wash away the portions corresponding to the conductor lands. Then, copper was electroless plated to the thickness of 5 μ on the conductor lands using the electroless copper plating bath "CP—70". It was then heated at 180°C for 60 minutes to form the circuit board of high circuit density having the platinum thin film resistors of 10 lines/mm fine pattern and the copper plated conductor lands.

WHAT WE CLAIM IS:—

1. A method for manufacturing a thin film resistor comprising the steps of:

depositing a continuous thin film resistor material layer on at least one main side surface of a dielectric substrate; and

selectively irradiating said thin film resistor material layer through a mask with high intensity light having an energy above a critical value at which said resistor material is dispersed at irradiated portions thereof to form a desired pattern of resistors in the remaining non-irradiated portions of said resistor material layer.

2. A method according to Claim 1 further comprising the step of forming a conductor pattern on the opposite side of said substrate, forming through-holes in said substrate, and forming conductive metal layers on the inner walls of said through-holes to electrically interconnect said resistor pattern to said conductor pattern.

3. A method according to Claim 1 further comprising the steps of forming said thin film resistor pattern and a conductor pattern on each side of said substrate, forming through-holes in said substrate, and forming conductive metal layers on the inner walls of said through-holes to electrically interconnect said resistor patterns and said conductor patterns on both sides of said substrate.

4. A method according to Claim 2 or 3 wherein said step of forming the resistor pattern includes the steps of forming said resistor pattern as a combined pattern of the desired resistor pattern and the desired conductor pattern and forming said conductor pattern on said resistor pattern.

5. A method according to Claim 4 wherein said step of forming the conductor pattern includes a step of selectively plating said resistor material layer with conductive metal through a plating resist.

6. A method according to Claim 5 wherein said plating resist is photosensitive epoxy resin.

7. A method according to Claim 2 wherein said step of forming the conductor pattern on the opposite side of said substrate includes the steps of depositing continuous thin film resistor material layer

on the opposite side of said substrate, forming a resistor material pattern as a plating base by pattern formation process using the high intensity light irradiation method, and plating said base with conductive metal to form the conductor pattern.

8. A method according to any one of Claims 1 to 7 wherein said thin film resistor material layer is deposited on the entire surface or selected portions of said substrate by vacuum deposition, sputtering or ion-plating.

9. A method according to Claim 8 wherein a polymer prime layer is formed on the surface of said substrate prior to the deposition of said resistor material layer.

10. A method according to any one of Claims 1 to 9 wherein said thin film resistor material layer is deposited to the thickness of 100 Å to 1 μ.

11. A method according to any one of Claims 1 to 10 wherein said substrate is formed of polyimide, polyamide, epoxy resin, polyester, polystyrene, polyethylene, polyparabanic acid or phenolic resin or a laminate including any of said resins.

12. A method according to any one of Claims 1 to 10 wherein said substrate is made of ceramic.

13. A method according to any one of Claims 1 to 12 wherein said resistor material comprises a member selected from Ni, Ru, Pt, Pd, W, Mo, Ta, a ruthenium oxide and a tantalum oxide.

14. A method according to any one of Claims 1 to 12 wherein said resistor material mainly comprises a member selected from Ni-Cr alloy, Co-P alloy, Ni-B alloy, Ni-P alloy, Ni-Ce alloy Cr-P alloy, Ce-P alloy, and Cr-B alloy.

15. A method according to Claim 1 substantially as described in any one of the Examples.

16. A method according to Claim 1 substantially as described herein with reference to Figs. 1, 2A and 2B, or Fig. 3, or Fig. 4, or Figs, 5A to 5E, or Figs, 6A to 6C of the accompanying drawings.

17. A thin film resistor produced by a method according to any one of Claims 1 to 16.

18. A hybrid integrated circuit or a printed circuit board comprising one or more thin film resistors produced by a method according to any one of Claims 1 to 16.

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FIG. 1

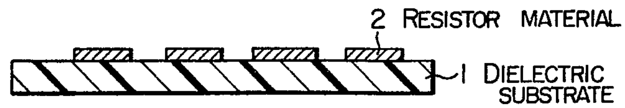

FIG. 2A

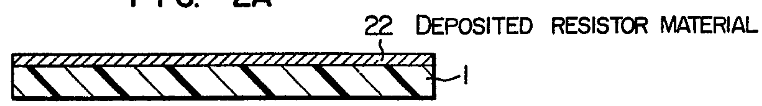

FIG. 2B

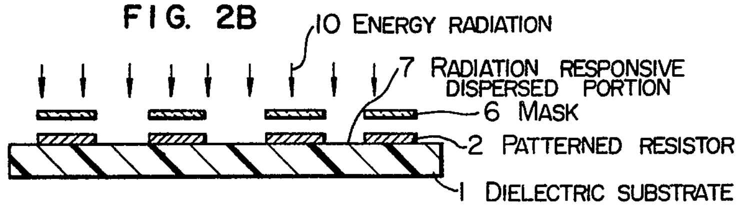

FIG. 3

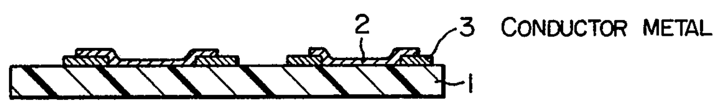

FIG. 4

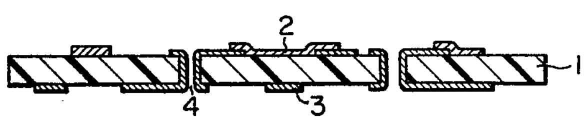

FIG. 5A

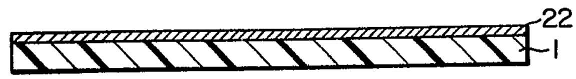

FIG. 5B

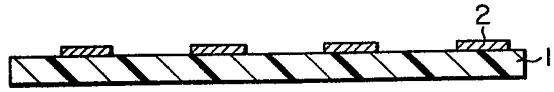

FIG. 5C

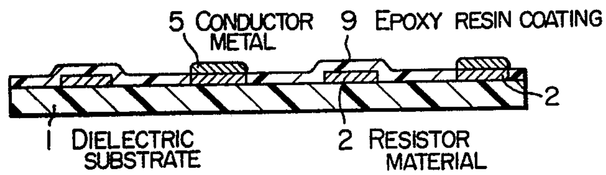

FIG. 5D

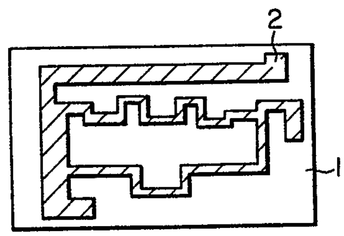

FIG. 5E

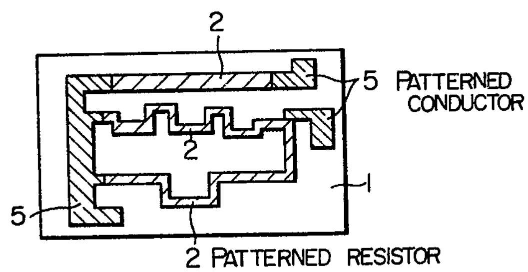

FIG. 6A

FIG. 6B

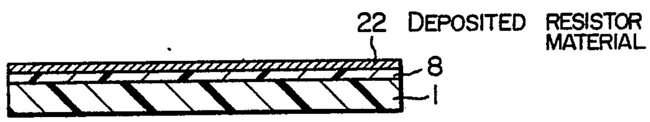

FIG. 6C