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(54) **Chip resistor for surface mounting and method of manufacturing a chip resistor for surface mounting**

(57) The present invention relates to a leadless chip resistor for surface mounting on a circuit board. Conventional leadless chip resistors have a single resistor layer 20 on the upper surface thereof between two conductive plates 50. The present invention proposes a double sided resistor chip, which has resistor layers 20, 320 on both

upper and lower faces of the substrate 10 and in conductive contact with electroplated conductive plates 50 which wrap around the ends of the substrate 10. This allows the resistor chip to have a higher pulse energy rating than a conventional surface mounted resistor of the same size. A method of manufacturing the resistor chip is also disclosed.

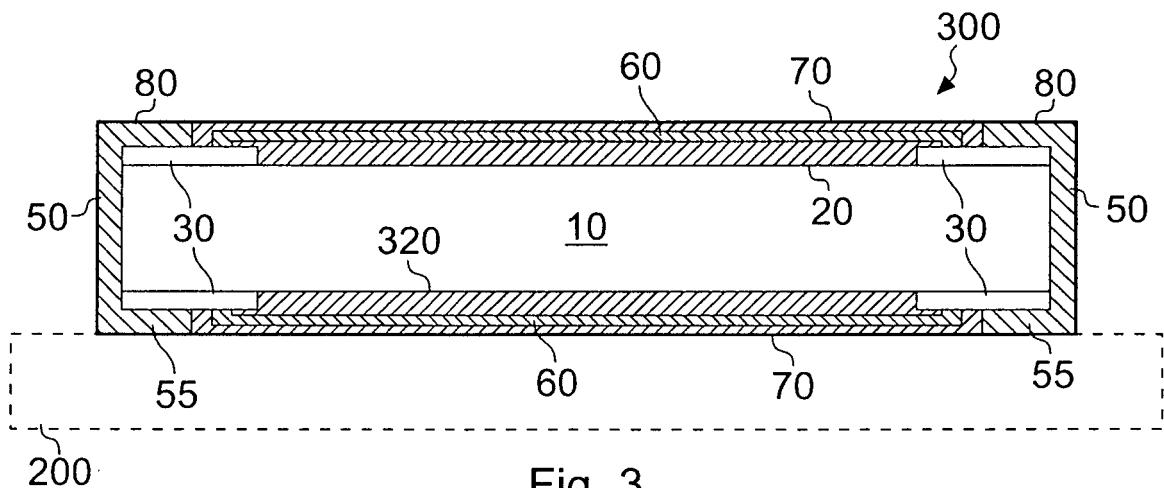


Fig. 3

Description

[0001] The present invention relates to a resistor and a method of manufacturing the resistor. In particular it relates to a surface mounted chip resistor which does not have a lead frame.

[0002] A typical surface mounted chip resistor is shown in Fig. 1. It comprises a ceramic substrate 10, having a thick film resistor 20 on a top surface thereof. Thick film printed conductor portions 30 are provided on either side of the thick film resistor 20 on the top surface of the substrate 10. Corresponding portions of thick film printed conductor 30 are also provided on the bottom surface 40 of the substrate 10. Conductor plates 50 are wrapped around each end of the substrate 10 and have portions resting on and in conductive contact with the thick film printed conductor sections 30. The conductor plates 50, have flat bottom surfaces 55 under the bottom 40 of the substrate. An over glaze layer 60 is provided over the thick film resistor 20 and acts as a protective coating. A further protective coating, in the form of an insulating epoxy layer 70, is provided over the over glaze layer 60. Ideally the epoxy layer 70 is flush with the upper surfaces 80 of the conductor plates 50.

[0003] In use the conductor chip is surface mounted onto a printed circuit board 200 such that the lower faces 55 of the conductive plates 50 rest over and are in electrically conductive contact with conductive lines of the circuit board 200. Usually, the resistor chip is attached by solder. Current can then be passed through the thick film resistor 20 of the resistor chip, via the conductive plates 50 which contact the circuit board 200 and thick film printed conductor sections 30 which are in conductive contact with the thick film resistor 20.

[0004] The surface mounted chip resistor described above is very different to the lead frame mounted resistors shown in Figs. 2a, and 2b. A through hole lead frame resistor 100, shown in Fig. 2a, has a resistor component 110, which is attached to a circuit board 200 by a pair of lead frame pins 120 which are inserted through holes 210 in the circuit board 200. The pins or wires 210 are then generally secured in place by solder. As can be seen in Fig. 2a, the resistor 110 is suspended above the circuit board by the wires or pins 120. The resistor component 110, in this example, comprises a substrate 110a in which is mounted a resistor element 110b. In Fig. 2a the resistor element 110b is in a serpentine pattern. Fig. 2b shows a surface mounted lead frame resistor in which the resistor component 110 has a lead frame with two wire legs 120 which are surface mounted onto the circuit board 200. In contrast a surface mounted resistor chip does not have a lead frame, instead its conductive terminal plates form an integral part of the chip which is mounted on the circuit board. Furthermore, the lead mounted resistor of the type shown in Fig. 2a and 2b are conventionally attached manually to the circuit board, whereas surface mounted chip resistors are suitable for automatic attachment to the circuit board. The flat conductor plates of the surface mount-

ed resistor chip make it easy to attach by high volume assembly processes by means of industry standard, automatic, high speed pick-and-place equipment.

[0005] Another difference is that lead frame mounted resistors are typically larger than 10mm x 6mm (dictated by the size of the lead frame), whereas the dimensions of a surface mounted resistor is typically, 6.5mm x 3.2mm or smaller (dimensions being measured as length x width, rather than depth, of a chip). In summary surface mounted chip resistors and lead frame resistors are quite different from each other and not considered by persons skilled in the art to be similar.

[0006] It would be desirable to provide a surface mounted chip resistor which has a higher pulse energy rating than a conventional surface mounted chip resistors without increasing its size. The pulse energy rating of a resistor is the safe limit to the amount of energy generated when a short pulse of given power and duration is passed through the resistor (above the safe limit the resistor may be destroyed).

[0007] Current attempts to achieve the above rely on minimising or omitting the laser trimming, which is conventionally used to cut the thick film resistor to achieve the desired ohmic value or size during the manufacturing process. That is current methods rely on avoiding or minimising removal of the resistive film.

[0008] Accordingly, at its most general, the present invention proposes providing a resistor element on both sides of the substrate. As the pulse energy rating for short pulses is proportional to the active resistive film area, providing two resistor elements effectively doubles the pulse energy rating for a chip of a given size.

[0009] A first aspect of the present invention may provide a leadless chip resistor for surface mounting on a circuit board, having:

- a substrate;
- a pair of electrically conductive plates mounted to at least a first face of the substrate, said conductive plates being configured for surface mounting on a circuit board;
- a first resistor layer on said first face of the substrate between said pair of conductive plates and in (electrically) conductive contact with said plates; and
- a second resistor layer on a second face of the substrate, opposite the first face, said resistor layer being in conductive contact with said pair of conductive plates.

[0010] By "leadless" it is meant that the resistor does not have a lead frame.

[0011] The conductive plates are configured for surface mounting on a circuit board. The surfaces for mounting on the circuit board may be substantially flat and are preferably parallel to each other so that the resistor can easily be laid down on the circuit board. The conductive plates need not be directly mounted on the substrate and there may be one or more intermediate layers between

the conductive plates and the substrate.

[0012] As the plates are on either side of the first resistor layer and in electrically conductive contact therewith, a current can be passed between the two plates through the first resistor layer. The first resistor layer need not be in direct contact with the conductive plates, but may be in conductive contact via an intermediate conductive element or layer. For example, an intermediate conductor mounted on the surface of the substrate between each conductive plate and the resistive layer. The second resistor layer is also in conductive contact (direct or indirect) with the conductive plates, so that current can be passed through both first and second resistor layers simultaneously.

[0013] By the above configuration, the resistor chip can have a higher pulse energy rating than a conventional surface mounted resistor of the same size (double if the resistive layers are of the same size). Furthermore, the above configuration allows for a lower minimum resistance than has previously been achievable with the same components. For example, if the second resistor layer is the same size as the first resistor layer, then the resistance will be approximately half that of single sided resistor only having the first resistor layer on a first face of the substrate. This is important in the area of low value current sense resistors, where minimum resistance is desirable. Furthermore, as two resistor layers are used, it may be possible to achieve higher manufacturing yields and therefore lower costs than for conventional surface mounted resistors.

[0014] Preferably the conductive plates wrap around the substrate, such that each conductive plate has a first portion on the first face of the substrate, a second portion on the second face of the substrate and an intermediate portion joining the first and second portions and wrapping round an edge of the substrate. Each conductive plate may take the form of an approximately U-shaped layer of material wrapping around an edge of the substrate. This makes it easy to connect the first and second resistor layers to the conductive plates. The conductive plates may be formed from an electroplated conductive epoxy resin.

[0015] Usually the dimensions of the, resistor chip will be 6.5mm x 3.2mm or less usually the dimensions will be at least 0.5mm x 0.25mm. Dimensions means the length x width of the chip.

[0016] The second resistor layer is usually the same size as the first resistor layer.

[0017] The substrate is not electrically conductive (i.e. it is an insulator). Preferably the substrate is made of a ceramic material.

[0018] The resistor layers may be made of any suitable material. Usually they will take the form of thick film resistors. Ruthenium components, e.g. ruthenium oxide, are particularly suitable for the resistor layers, but alternatives will be apparent to a person skilled in the art.

[0019] In one embodiment intermediate conductors are provided on the substrate at both ends of and in con-

tact with each resistor layer on both faces of the substrate. The conductive plates wrap over and connect intermediate conductor sections on opposite faces of the substrate.

[0020] Preferably one or more protective and/or insulating layers are provided over the resistor layers and/or the intermediate conductors. Preferably the outermost protective or insulating layer is flush with the surface of the conductive plates. This provides a smooth surface for the resistor enabling it to be easily mounted on a circuit board. However it is possible for the protective or insulating layer to be recessed relative to the surface of the conductive plates. Protective layers help to prevent corrosion of the resistor layers and intermediate conductors, while insulating layers help to prevent shorting of the resistor.

[0021] Preferably an over glaze is provided on one or both faces of the resistor, covering the surface of the resistor layer(s). The over glaze helps to protect the internal parts of the resistor from corrosion.

[0022] Preferably an epoxy layer is provided over the resistor layer and over the over glaze (if present). The epoxy layers help to insulate the resistor layer(s) and help prevent shorting between the conductive plates.

[0023] A second aspect of the present invention may provide a method of making a leadless chip resistor comprising placing or forming a first resistor layer on a first face of a substrate and forming or placing a second resistor layer on a second face of the substrate, opposite the first face, forming or placing electrically conductive plates on both sides of said first resistor layer on said first face of said substrate, such that said conductive plates are in electrical contact with said resistor layers and adapted for surface mounting on a circuit board.

[0024] The resistor layers may be formed by printing and firing resistive materials (preferably thick film) onto the substrate (which is preferably ceramic). The conductive plates may be electroplated.

[0025] Preferably a plurality of resistor layers are formed on both faces of a substrate and the substrate is subsequently cut, snapped or otherwise separated into separate sections (typically strips comprising a row of one or more resistor chips). The conductive plates are preferably placed or formed after this separation.

[0026] Separate intermediate conductor layers or sections for electrically connecting the resistor layers with the conductive plates can be formed on the substrate as well. If a plurality of resistor layers are formed on the substrate, before the substrate is broken into separate sections, then the intermediate conductors are preferably formed before this separation step. The intermediate conductors may be formed by printing and firing a conductive material onto the substrate.

[0027] Preferably an over glaze layer is added to cover the resistive layers. Preferably a laser is used to adjust the ohmic value (by shape or size trimming) of the resistor layers, by trimming off unnecessary portions. An epoxy layer may also be added, for example over the resistor

layer or the over glazed layer (where present). Generally, these steps will be carried out before the substrate is separated into separate sections.

[0028] Preferably the conductive plates are such that they wrap around ends of the substrate to extend over both first and second faces of the substrate. Preferably the conductive plates are formed by dipping the ends of the resistor chip into a conductive resin. Preferably the conductor plates are electroplated.

[0029] The method of the second aspect of the present invention may be adapted to use components or produce resistor chips having any of the features described in the first aspect of the present invention.

[0030] An embodiment of the present invention will now be described with reference to the accompanying drawings in which;

Fig. 1 is a cross-sectional view of a single sided surface mount resistor chip and has already been described above;

Figs. 2a and 2b shows two types of lead frame mounted resistor and has already been described;

Fig. 3 is a cross-sectional view of a resistor chip according to the present invention;

Fig. 4 shows steps in the first stage in the manufacturing process of the chip of Fig. 3; and

Fig. 5 shows manufacturing steps in the second stage of the manufacturing process.

[0031] Fig. 3 shows a resistor chip 300 according to an embodiment of the present invention. It comprises a ceramic substrate 10 (which is an insulating material), a first thick film resistor 20 mounted on a first (upper) face of the substrate 10 and a second thick film resistor 320 mounted on a second face of the substrate 10 opposite to the first face. In this embodiment the thick film resistors are parallel to each other and extend approximately $\frac{3}{4}$ of the length of the substrate. On each face of the substrate 10, intermediate or internal conductors 30 in the form of thick film printed conductor sections, are mounted on either side of the thick film resistors 20, 320 and cover the remainder of each face of the substrate 10. Electroplated conductive plates 50 are wrapped around the ends of the substrate 10 and over a portion of the intermediate conductors 30. The conductor plates 50 thus have a cross-section corresponding approximately to a square U-shape. The legs of the U form substantially flat sections 55 and 80 on either side and parallel to the upper and lower sides of the substrate 10. These flat surfaces 55 act as conductive terminals when the resistor 300 is mounted on a circuit board 200 (shown in dotted lines in Fig. 3). Alternatively the resistor could be mounted the other way up with the flat surfaces 80 acting as conductive terminals.

[0032] Each electrically conductive plate 50 wraps around the ends of the substrate 10, as described above, and thus puts the intermediate conductors 30 which it contacts on opposite faces of the substrate 10 in electri-

cally conductive contact with each other. In this way current can be passed through both the first 20 and second 320 resistor layers when the device is in use.

[0033] As there is a resistor layer (in this embodiment a thick film resistor) on either face of the substrate 10, the pulse energy rating of the resistor chip is increased and the resistance is smaller than if there was only a single resistor on one face of the substrate.

[0034] An over glaze layer 60 is provided over each face of the resistor chip 300 covering the respective resistor layer 20, 320 on each face of the substrate 10. The overglaze layer 60 is itself covered with an epoxy layer 70 which has an outer surface, preferably flush with the outer surface of the conductor plates 50 to form a smooth consistent surface for mounting on the printed circuit board 200.

[0035] The resistor chip 300 can be attached to the printed circuit board 200 by solder and this may be carried out automatically with the aid of a machine. Suitable machines are well known and standard in the industry.

[0036] The method of manufacturing the resistor chip will now be described. This is similar to the conventional method for manufacturing a single sided resistor chip (i.e. a resistor chip with only a single resistive layer on one face thereof), but certain steps have to be carried out twice so that components are applied to both faces of the substrate and special care has to be taken to make sure that the components are not too thick on either face. In contrast to the conventional single sided resistor chip shown in Fig. 1, the resistor chip of the present embodiment can be surface mounted on either face, both of which have components, so it is necessary to make sure that neither the resistor layer, over glaze layer or epoxy layer are too thick. Preferably they are flush with the outer surfaces of the conductive plates.

[0037] In broad terms the manufacturing method has two stages. In the first stage, shown in Fig. 4, various components are added to a ceramic substrate 10 in a printing and firing process. In the second stage, shown in Fig. 5, the coated substrate is snapped into a plurality of separate sections and the conductive plates are then formed.

[0038] In Fig. 4, at step 410, a plurality of conductive layers 30 are formed by printing and firing conducting material onto a first (rear) face of the substrate 10. These conductive layers 30 later form the intermediate conductors 30 described above.

[0039] In step 420 the same printing and firing process is carried out to form corresponding conductive layers 30 on the second (front) face of the substrate 10.

[0040] In step 430 resistor layers 20 are then formed by printing and firing resistive thick film materials onto the first face of the substrate 10. These resistor layers 20 are formed between and contact the conductor layers 30 which were formed previously. This step 430 is then repeated for the second face of the substrate 10.

[0041] At step 440 an overglaze layer is formed by printing and firing an over glaze material on to the first

face of the substrate 10, so that the resistive layers 20 are covered. This step is then repeated for the second face of the substrate 10.

[0042] At step 450 a laser is used to obtain the desired ohmic value for then resistor layer 20 by trimming off any unwanted portions of the resistor layers 20. This step is then repeated for the resistors on the second face of the substrate 10.

[0043] In step 460 printing and curing is carried out on the first and second faces to add a protective layer.

[0044] In step 470 each resistor is marked.

[0045] Thus far, a plurality of separate resistors have effectively been formed as a grid on the same substrate. This is then snapped into strips, each comprising a plurality of resistors in a single row, in step 480 which is shown in Fig. 5.

[0046] In step 490 each strip is dipped into a conductive epoxy resin, so as to provide a conductive path around the ends of each resistor chip on the strip. The conductive epoxy resin thus forms the conductive plates 50 shown in Fig.3

[0047] In step 500 each strip is separated into separate sections by snapping, cutting or otherwise. Then in step 510 the conductive plates formed by the conductive resin are electroplated to enhance their solderability.

[0048] In step 520 each chip is officially inspected for flaws. Then in step 530 chips which pass this step are measured to check their ohmic value.

Claims

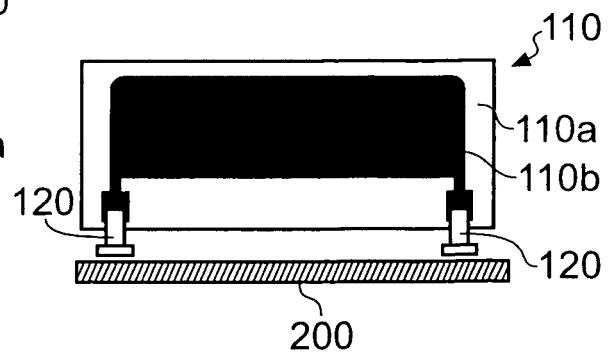
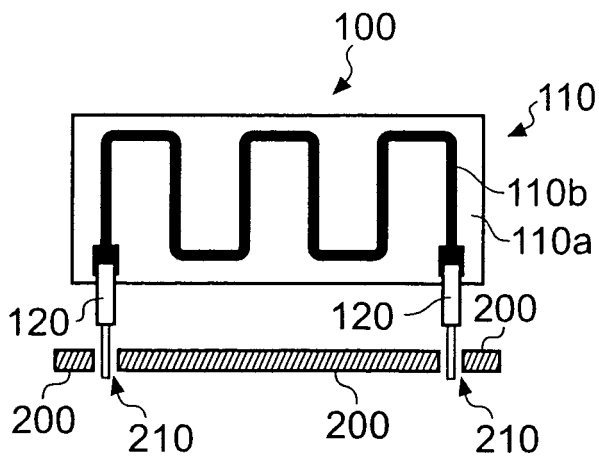
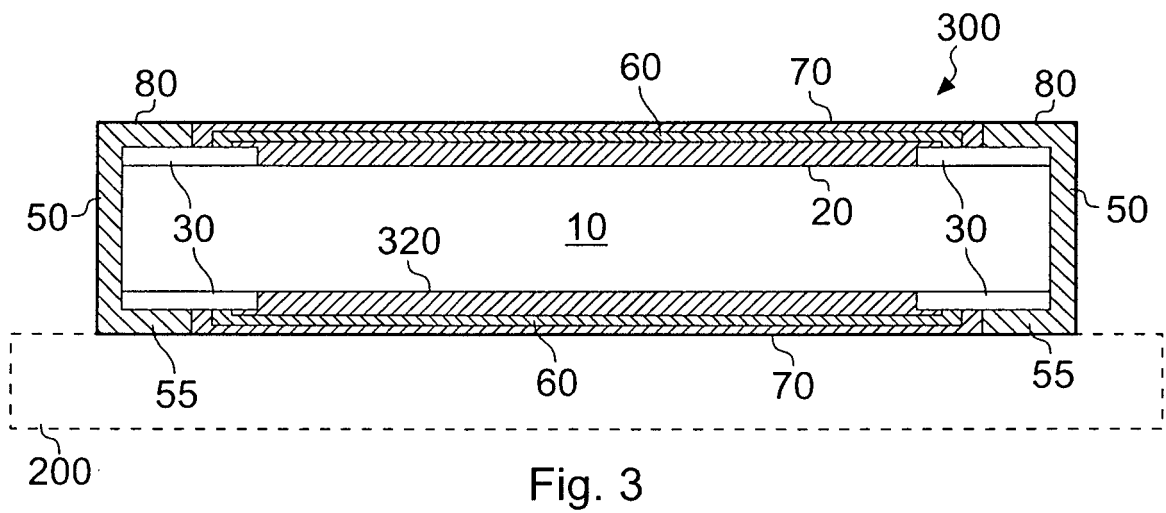
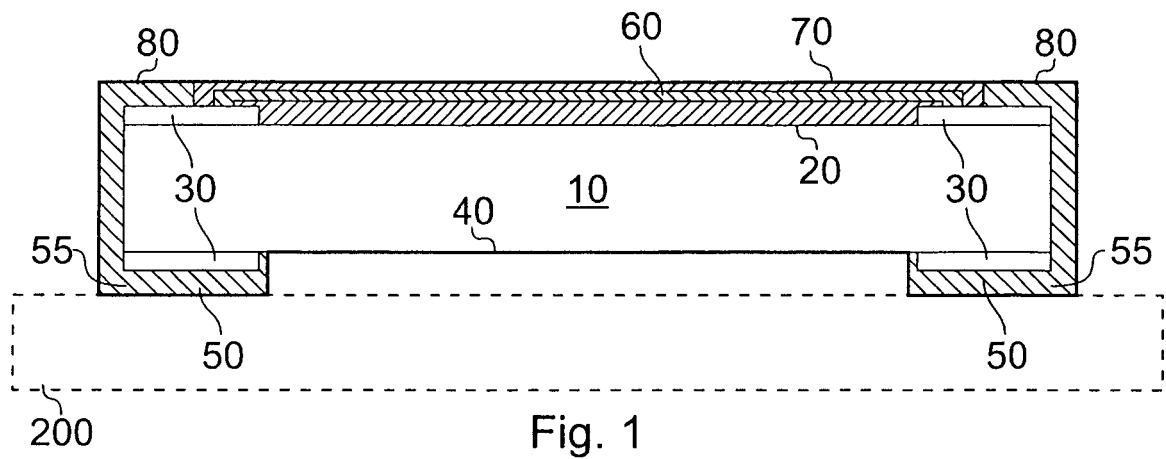
1. A leadless chip resistor for surface mounting on a circuit board, having:

a substrate;
a pair of electrically conductive plates mounted to at least a first face of the substrate, said conductive plates being configured for surface mounting on a circuit board;
a first resistor layer on said first face of the substrate between said pair of conductive plates and in conductive contact with said plates; and
a second resistor layer on a second face of the substrate, opposite the first face, said second resistor layer being in conductive contact with said pair of conductive plates.

2. A resistor according to claim 1 wherein the conductive plates wrap around the substrate, such that each conductive plate has a first portion on the first face of the substrate, a second portion on the second face of the substrate and an intermediate portion joining the first and second portions and wrapping round an edge of the substrate.
3. A resistor according to claim 1 or claim 2 wherein the dimensions of the chip resistor are 6.5mm x

3.2mm.

4. A resistor according to any one of the above claims wherein the conductive plates are formed from an electroplated conductive epoxy resin.
5. A resistor according to any one of the above claims wherein the resistor layers are in conductive contact with the conductive plates via intermediate conductors provided on the substrate between the resistor layers and said conductive plates.
6. A resistor according to any one of the above claims wherein one or more protective and/or insulating layers are provided over the resistor layers.
7. A method of making a leadless chip resistor comprising placing or forming a first resistor layer on a first face of a substrate and forming or placing a second resistor layer on a second face of the substrate, opposite the first face, forming or placing electrically conductive plates on both sides of said first resistor layer on said first face of said substrate, such that said conductive plates are in electrical contact with said resistor layers and adapted for surface mounting on a circuit board.
8. A method according to claim 7 wherein the dimensions of the chip resistor are 6.5mm x 3.2mm.
9. A method according to claim 7 or 8 wherein the conductive plates are such that they wrap around ends of the substrate to extend over both first and second faces of the substrate.
10. A method according to claim 9 wherein the conductive plates are formed by dipping the ends of the resistor chip into an electrically conductive resin.
11. A method according to any one of claims 7 to 10 wherein a plurality of resistor layers are formed on both faces of a substrate and the substrate is subsequently cut, snapped or otherwise separated into separate sections.
12. A method according to claim 11 wherein the conductive plates are placed or formed after separation of the substrate into separate sections.



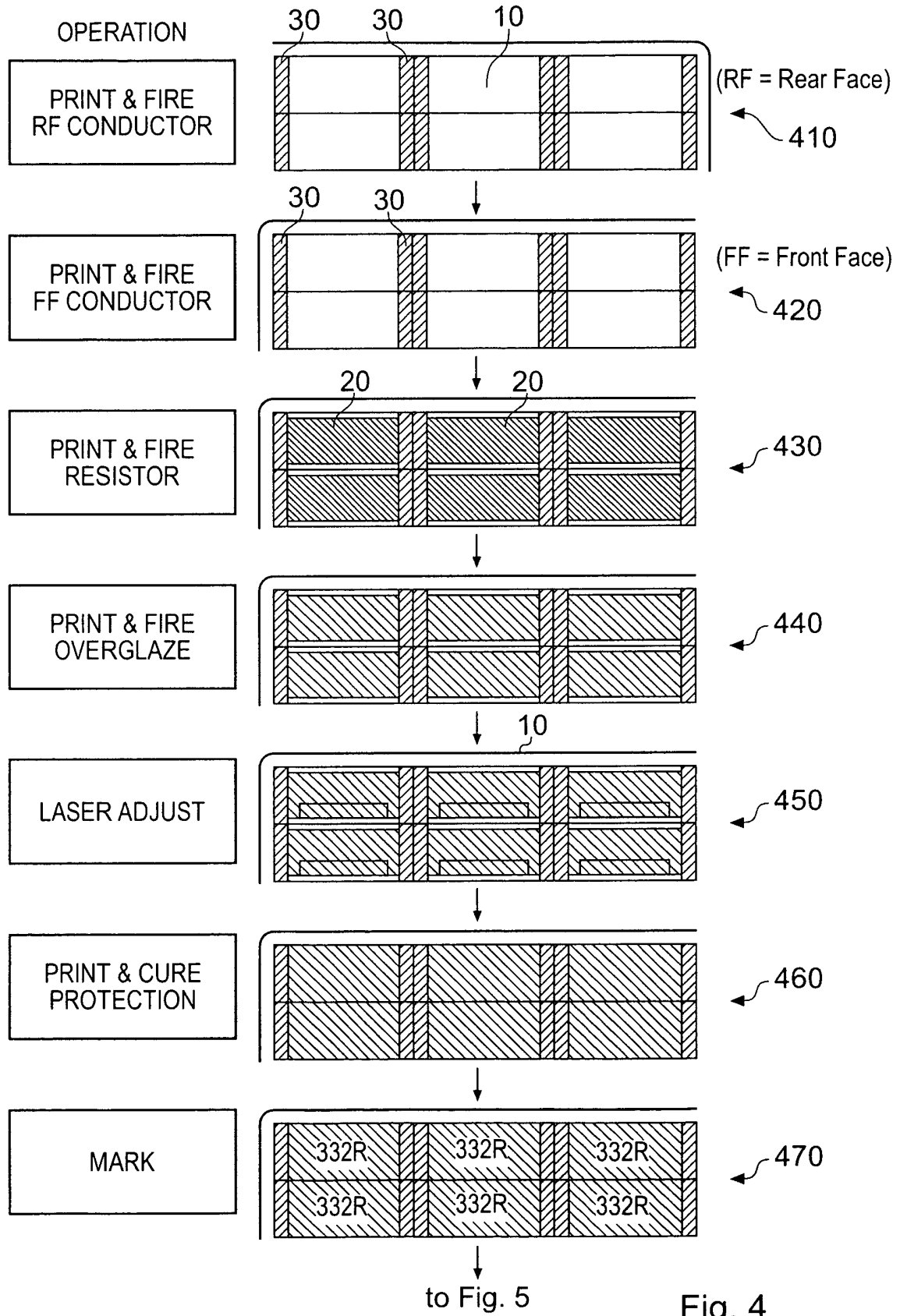


Fig. 4

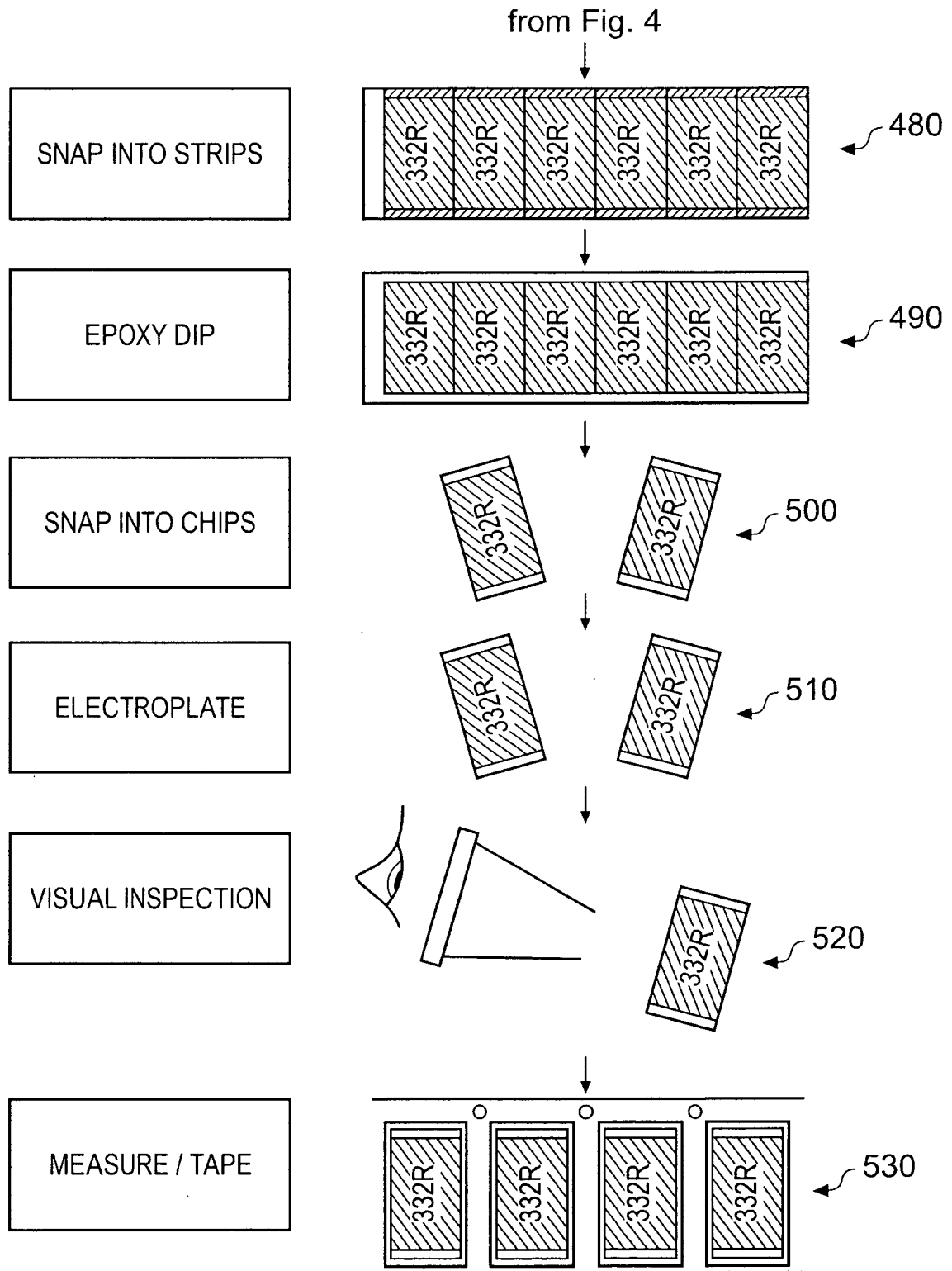


Fig. 5