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(54) **METHOD OF MANUFACTURING AN ELECTRICAL COMPONENT ON A SUBSTRATE**

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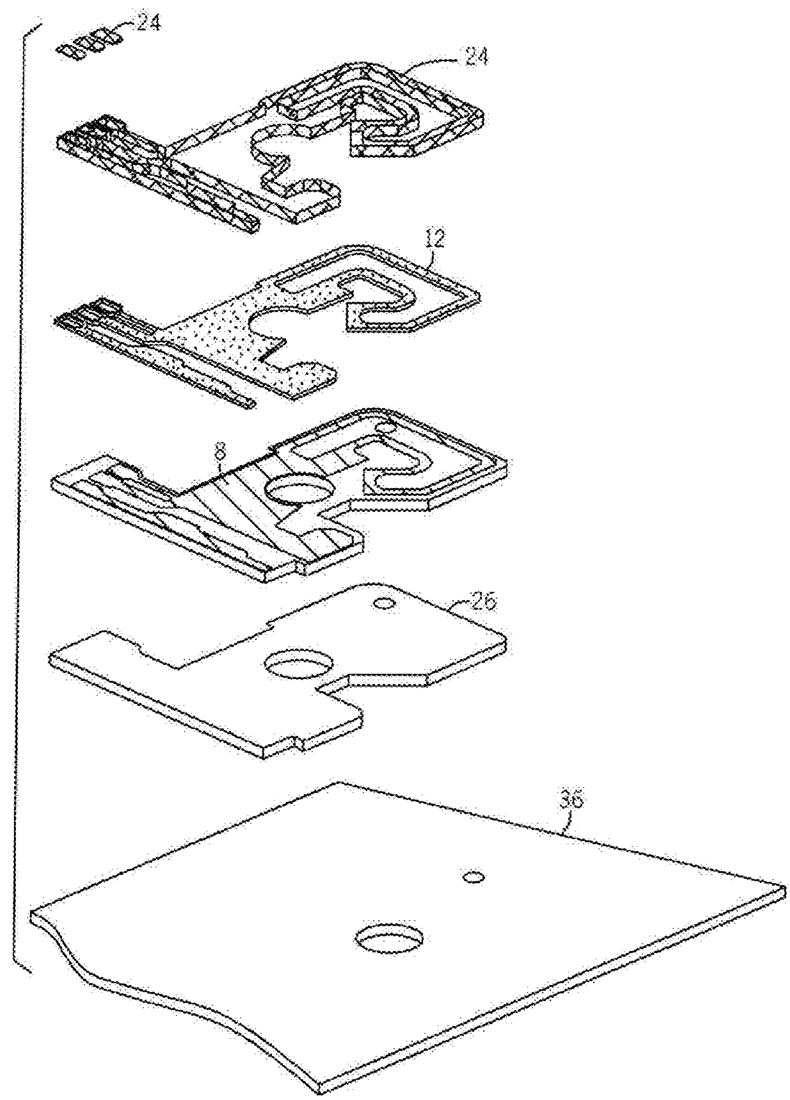
(57) **ABSTRACT**

Electrical components, e.g., a radiator for a cell phone circuit, are manufactured by a method comprising the steps of: (A) providing a substrate, e.g., a polymeric film, having a first facial side that has a metal coating, e.g., copper, and a second facial side that does not have a metal coating; (B) applying a covering material that is impervious to etching and plating, e.g., solder-mask, to the metal coating to define a trace except for its contact spot; (C) applying etch-resist to the metal coating to define the contact spot; (D) etching the metal coating from the substrate that is not covered by the covering material or etch-resist; (E) removing the etch-resist from the metal coating; and (F) plating the uncovered metal coating with a plating material comprising at least one of silver, gold, and nickel.



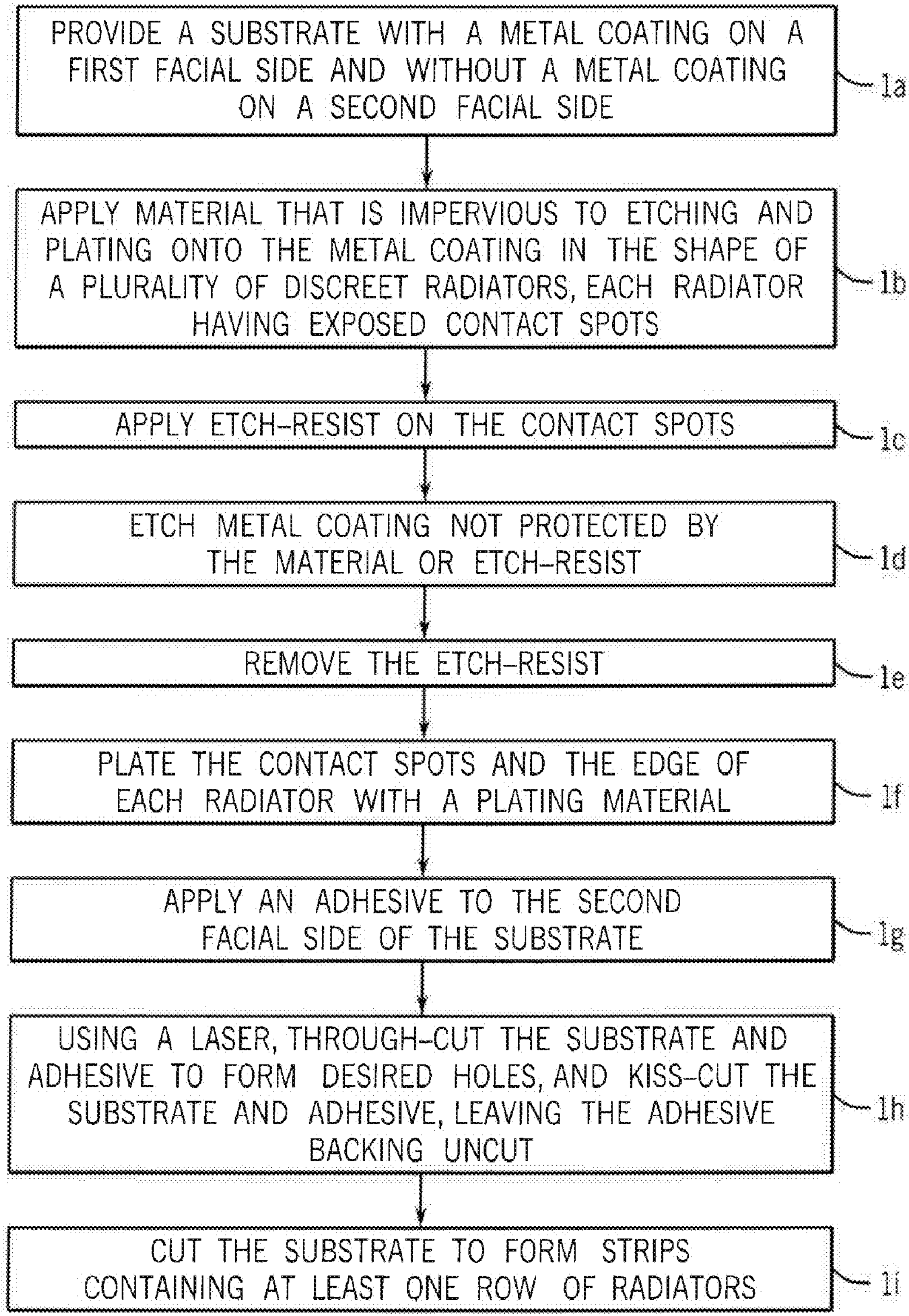

PROVIDE A SUBSTRATE WITH A METAL COATING ON A FIRST FACIAL SIDE AND WITHOUT A METAL COATING ON A SECOND FACIAL SIDE
1a
APPLY MATERIAL THAT IS IMPERVIOUS TO ETCHING AND PLATING ONTO THE METAL COATING IN THE SHAPE OF A PLURALITY OF DISCREET RADIATORS, EACH RADIATOR HAVING EXPOSED CONTACT SPOTS
1b
APPLY ETCH-RESIST ON THE CONTACT SPOTS
1c
ETCH METAL COATING NOT PROTECTED BY THE MATERIAL OR ETCH-RESIST
1d
REMOVE THE ETCH-RESIST
1e
PLATE THE CONTACT SPOTS AND THE EDGE OF EACH RADIATOR WITH A PLATING MATERIAL
1f
APPLY AN ADHESIVE TO THE SECOND FACIAL SIDE OF THE SUBSTRATE
1g
USING A LASER, THROUGH-CUT THE SUBSTRATE AND ADHESIVE TO FORM DESIRED HOLES, AND KISS-CUT THE SUBSTRATE AND ADHESIVE, LEAVING THE ADHESIVE BACKING UNCUT
1h
CUT THE SUBSTRATE TO FORM STRIPS CONTAINING AT LEAST ONE ROW OF RADIATORS
1i

FIG. 1

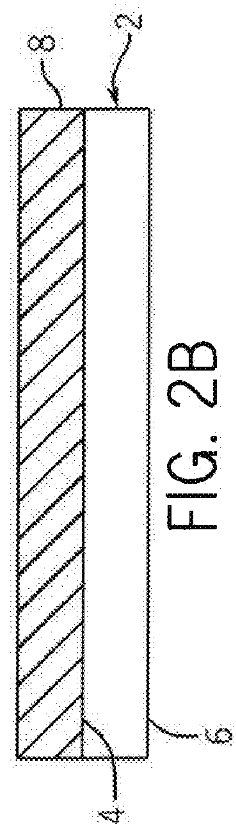


FIG. 2B

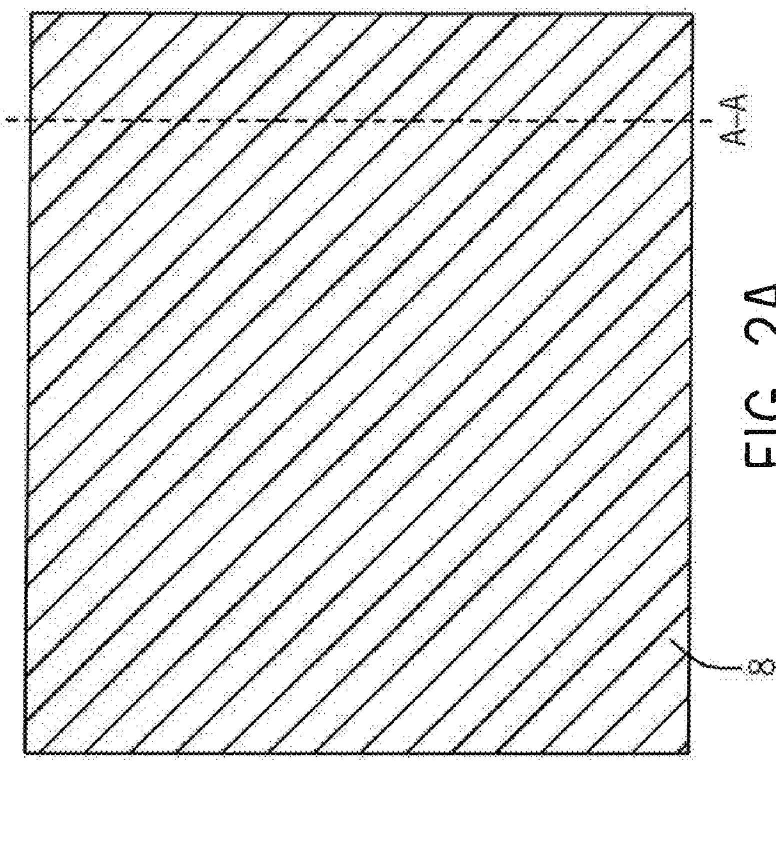


FIG. 2A

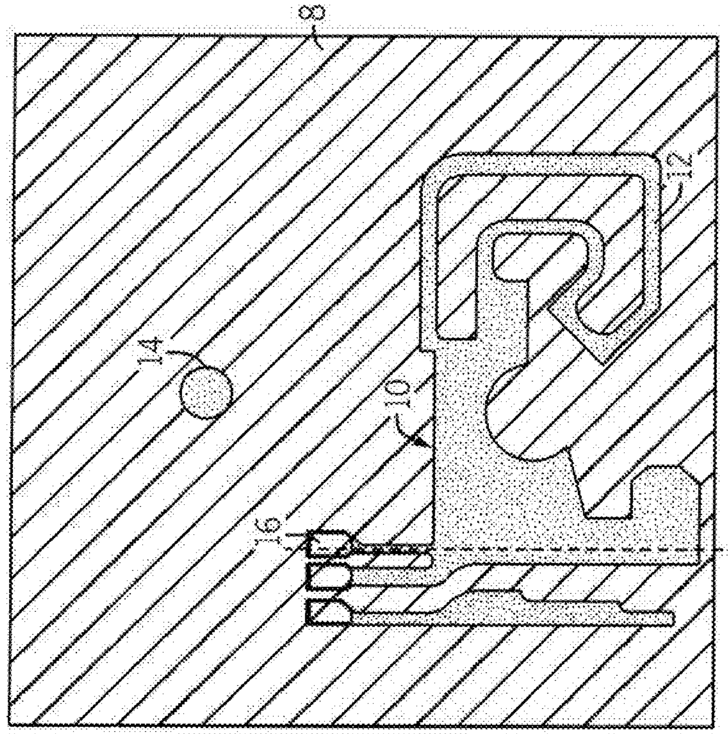


FIG. 3B

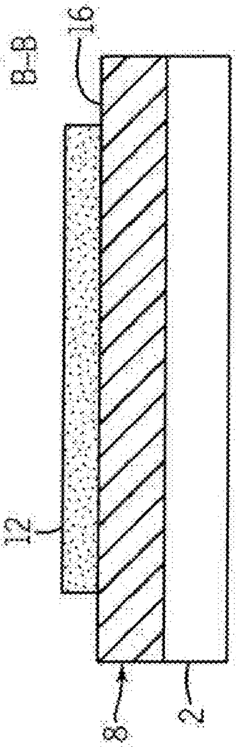


FIG. 3C

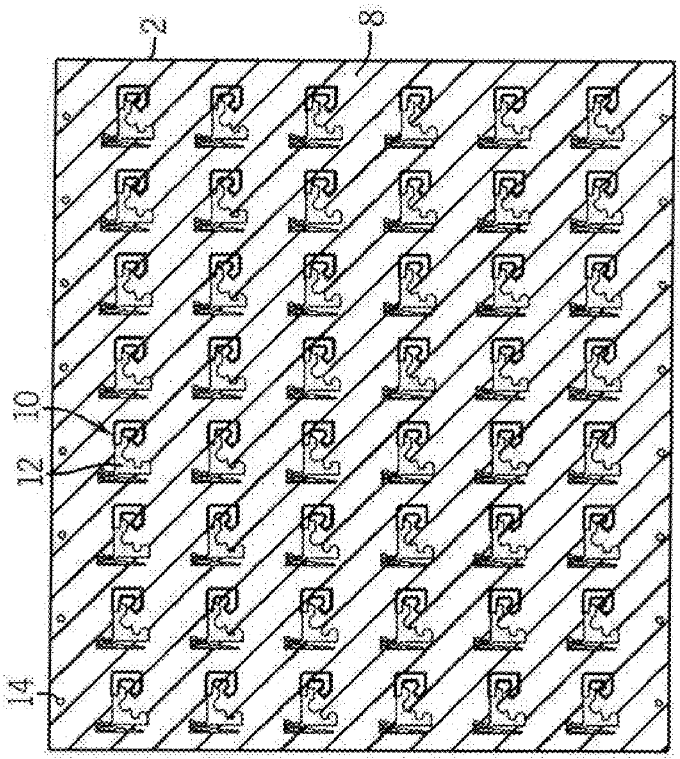


FIG. 3A

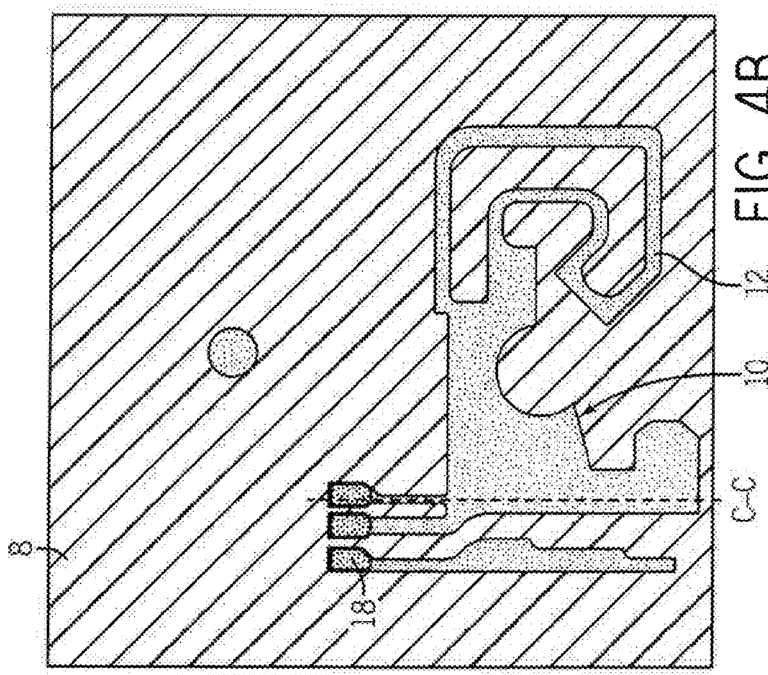


FIG. 4B

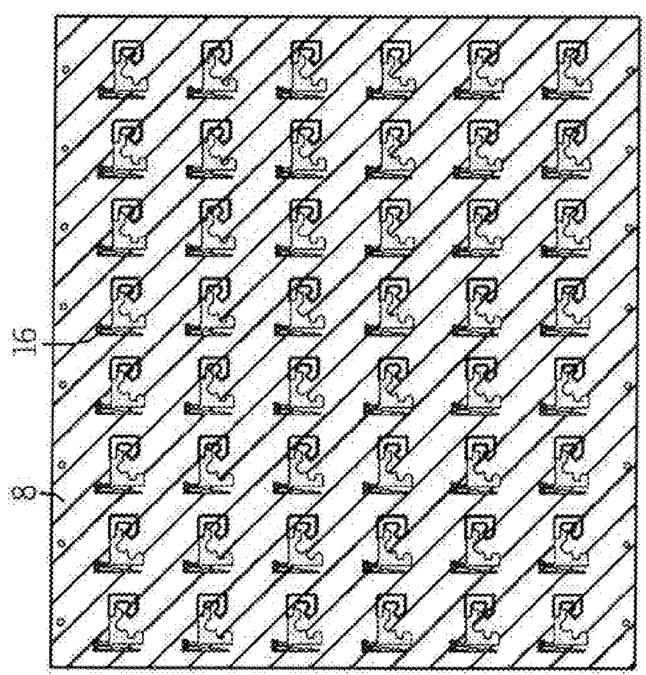


FIG. 4A

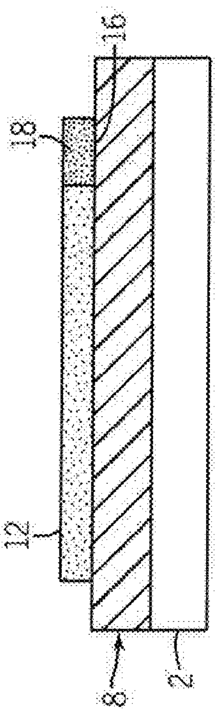


FIG. 4C

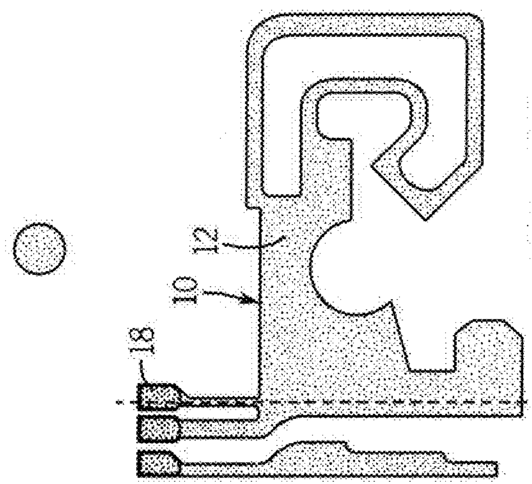


FIG. 5B

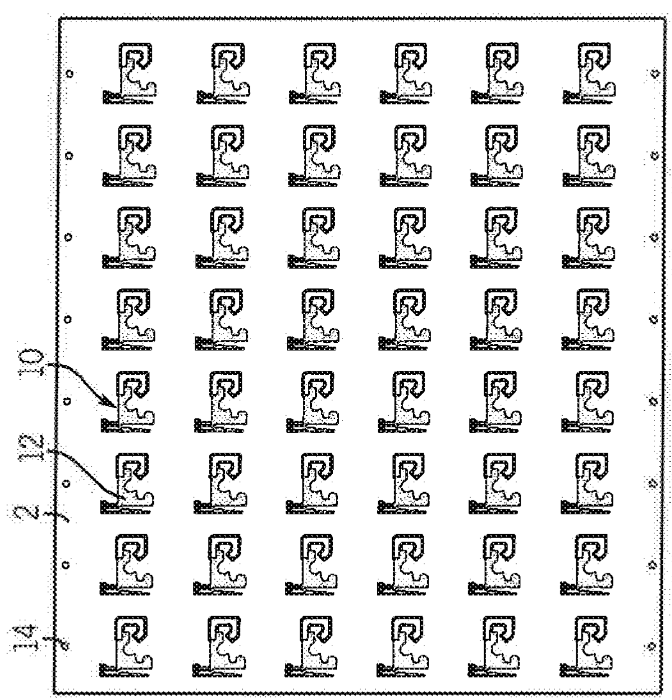


FIG. 5A

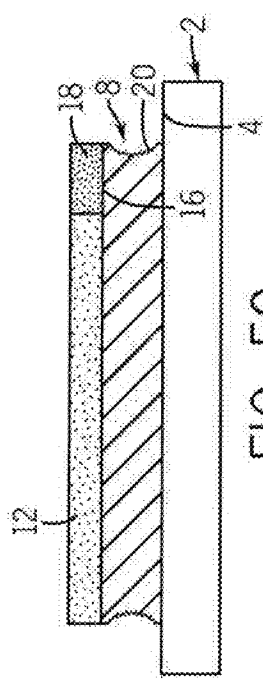


FIG. 5C

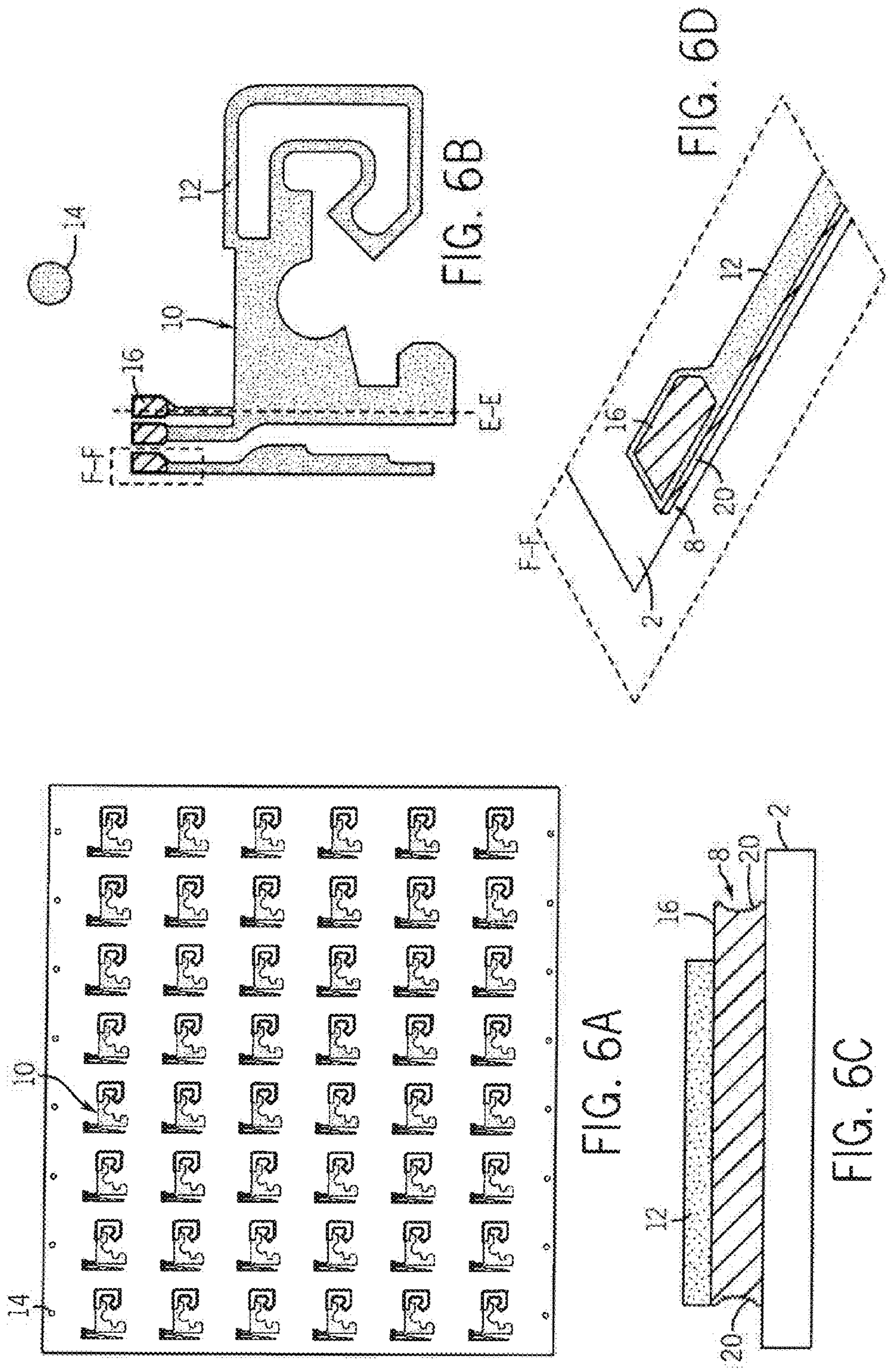


FIG. 6B

FIG. 6D

FIG. 6A

FIG. 6C

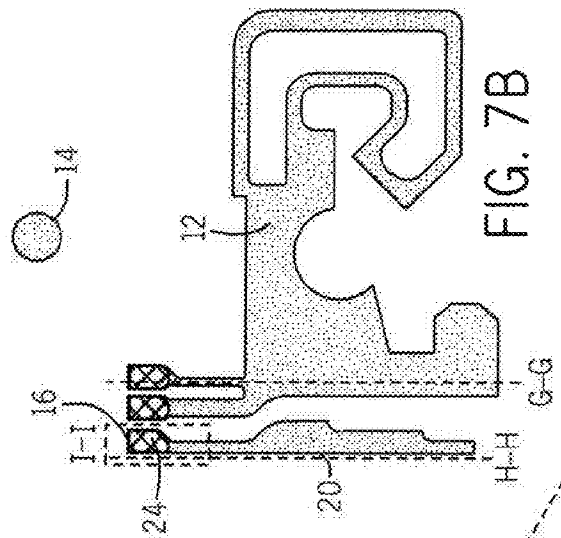


FIG. 7B

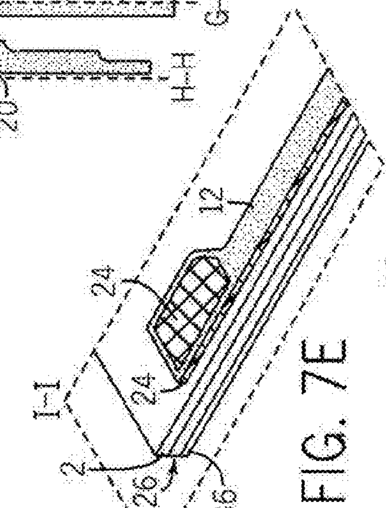


FIG. 7E

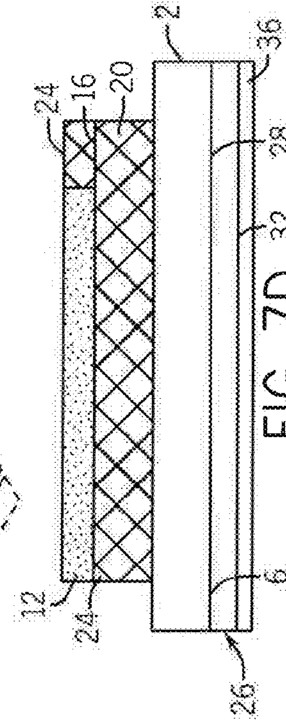


FIG. 7D

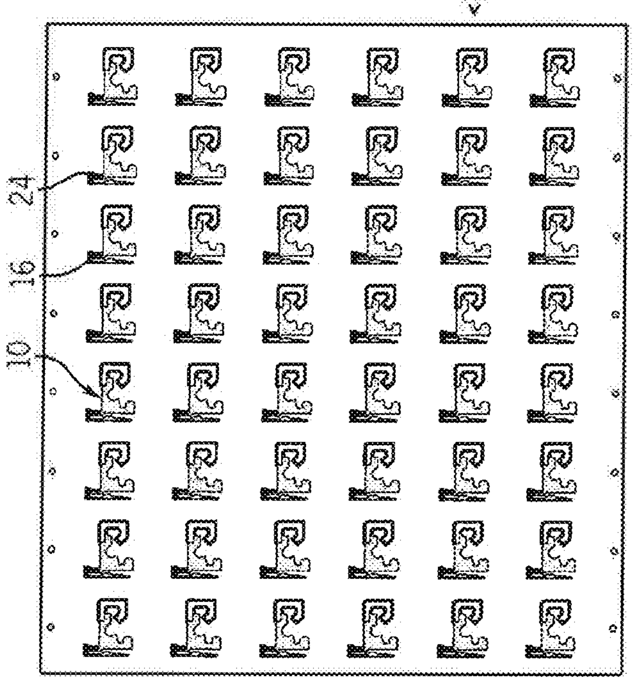


FIG. 7A

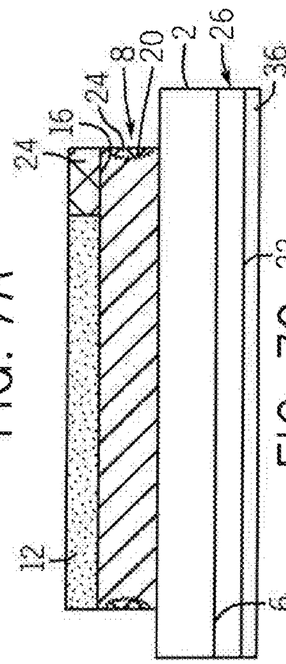


FIG. 7C

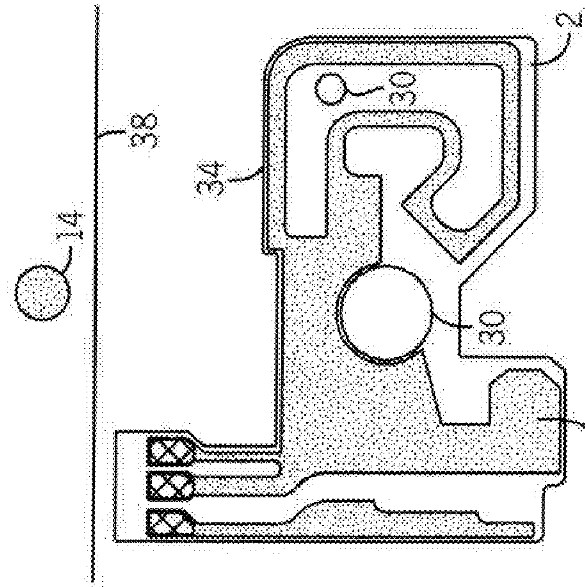


FIG. 8B

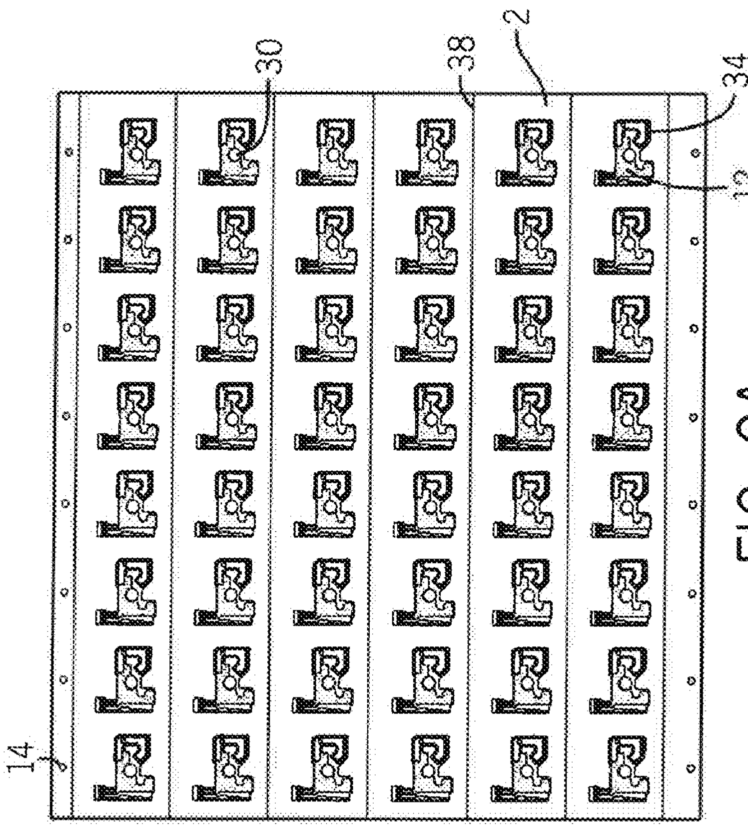


FIG. 8A

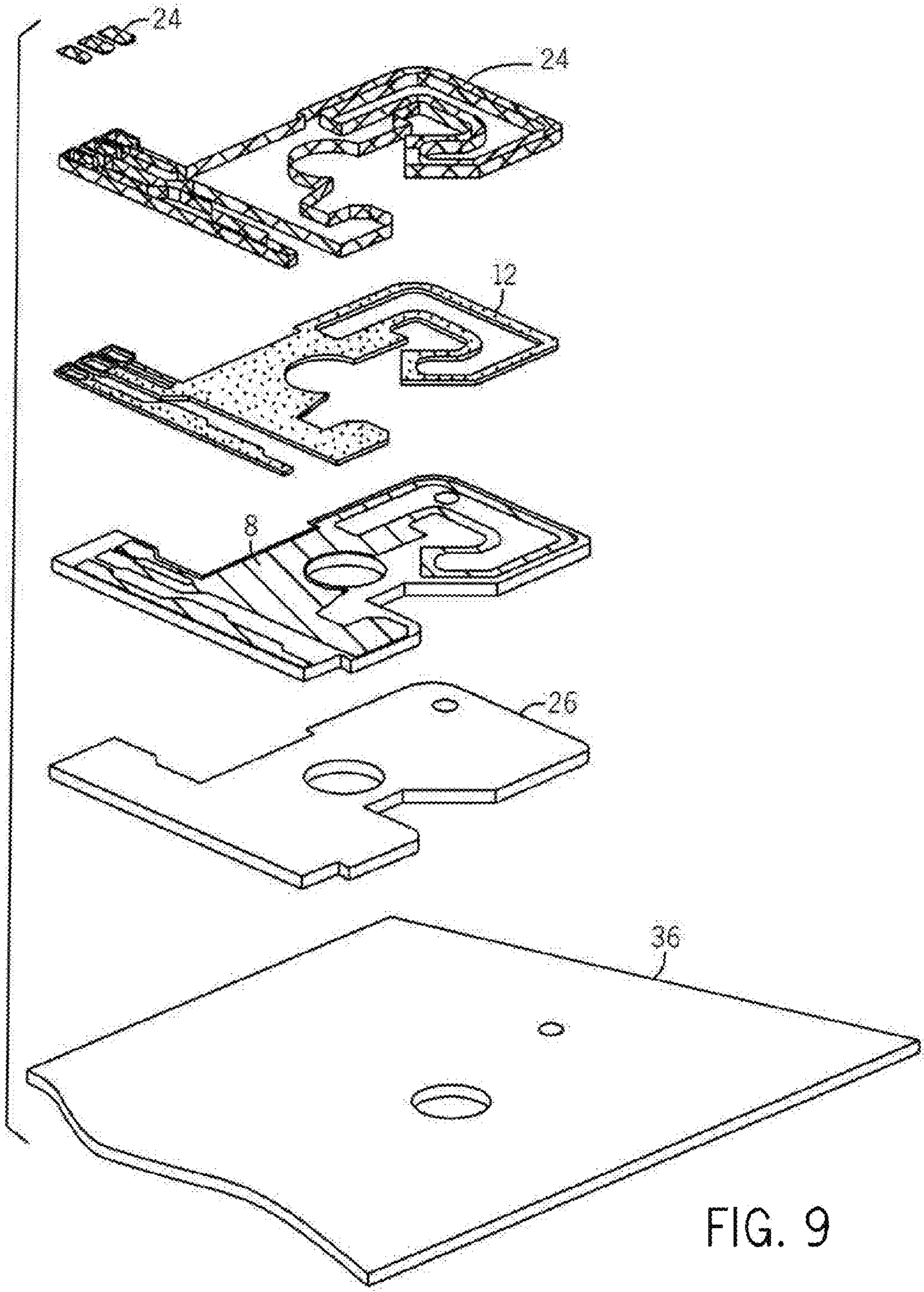


FIG. 9

METHOD OF MANUFACTURING AN ELECTRICAL COMPONENT ON A SUBSTRATE

FIELD OF THE INVENTION

[0001] The present invention relates generally to a method of manufacturing an electrical component on a substrate. In one aspect, the invention relates to the production of flexible printed circuits while in another aspect, the invention relates to a method of making radiators useful in the construction of cell phones, computers and the like.

BACKGROUND OF THE INVENTION

[0002] Various types of electrical circuits are manufactured through the use of an etch-resist printing method. This method involves various steps which are described below. Etch-resist printing may be used on both rigid and flexible substrates. When used with a flexible substrate the circuit is called a flexible printed circuit (FPC). FPC's offer the benefit of providing a relatively thin and flat profile that is bendable and can be manipulated easily without fracturing. This enables FPC's to be used in applications that have shape and size restrictions, e.g., computers, cell phones and the like. In addition, FPC's offer a reduced weight over printed circuits using heavier, rigid substrates which add to their portability.

[0003] An FPC can include one or more of various electrical circuit components, such as a radiator. To maximize manufacturing efficiency, many copies of one component are typically manufactured on a single substrate and then later separated for individual use. To manufacture an FPC that includes one or more components, various steps must be performed. First, a metal, e.g., copper is applied to a flexible substrate. Then etch-resist is printed on top of the metal to outline one or more components, a contact strip, and robber/buzz bars. The robber/buzz bars interconnect the components with the contact strip and will be used to facilitate an electroplating process by providing a path for electricity to all of the metal on the substrate, as discussed below. After the etch-resist has been applied, the uncovered or exposed metal is stripped away using an etching process. This process leaves only the etch-resist covered portions of metal on the substrate. The etch-resist is then stripped away revealing the remaining metal. Solder-mask is then applied to large areas of the substrate to substantially cover the components and robber bars with die exception of component contact spots. This often requires the use of excessive solder-mask. The contact spots are later used to electrically couple the component to another component. The solder-mask protects the metal from oxidation and limits the sections of metal that will be electroplated.

[0004] Traditionally, the electroplating process is performed by exposing the substrate to a solution containing positively charged nickel and gold ions. Electricity is applied to the contact strip creating a negative charge at the contact spots. The opposite charges of the nickel and gold ions and the metal, e.g., copper, create an attraction that couples the ions with the exposed metal of the contact spots. Further, the absolute thickness of the nickel and gold plating is often greater than ideally necessary due to irregularities (high and low points) in the thickness of the plating along the surface of the metal. Without compensation the low points along the surface would otherwise fall below desired specification for minimum plating thickness.

[0005] After electroplating an adhesive is applied to the facial side of the substrate opposite the facial side of the substrate that is carrying the components, and the substrate is then cut. Due to the existence of the metal contact strip and the robber bars, the substrate requires a die tool, such as a flatbed die tool, to cut the substrate into individual components or strips of substrate containing one or more components. Further, the robber bars and contact strip may contribute to the waste of raw materials as they occupy space on the substrate that may have been used to manufacture additional components.

[0006] In addition, the components often require one or more holes to be created for mounting or weight reduction. These holes are punched through the substrate and adhesive, and can require both male and female-type cutting tools. These tools are often difficult and expensive to obtain and are inflexible when the size or shape of a hole requires modification. Due to the excessive lead time to obtain these tools, a spare tool is typically required to ensure that production is not impeded should a tool break. In addition these tools require frequent servicing to re-sharpen their blades.

BRIEF SUMMARY OF THE INVENTION

[0007] In one embodiment the invention relates to a method of manufacturing an electrical component, e.g., a radiator, that comprises a trace that comprises a contact spot, the method comprising the steps of:

[0008] A. Providing a substrate having a first facial side that has a metal coating, e.g., copper, and a second facial side that does not have a metal coating;

[0009] B. Applying a covering material that is impervious to etching and plating, e.g., solder-mask, to the metal coating to define the trace of the electrical component except for the contact spot;

[0010] C. Applying etch-resist to the metal coating to define the contact spot of the trace;

[0011] D. Etching from the substrate the metal coating not covered by the covering material or etch-resist;

[0012] E. Removing the etch-resist from the metal coating; and

[0013] F. Plating the uncovered metal coating with a plating material comprising at least one of silver, gold and nickel.

[0014] In one embodiment the plating material is applied to the metal coating to form a substantially uniform thickness of plating material across the surface of uncovered metal coating.

[0015] In one embodiment the method also includes applying an adhesive to the second facial side of the substrate, and cutting through the substrate and, optionally, the adhesive with a laser.

[0016] In one embodiment the method includes cutting holes through the substrate and, optionally, the adhesive.

[0017] In one embodiment a plurality of radiators is manufactured on a substrate to which the covering material is applied in a matrix comprising at least two rows.

[0018] In one embodiment the substrate is cut into strips that are collected onto at least one roll.

[0019] In one embodiment the invention is a method of manufacturing radiators on a polymeric film, the radiators comprising a trace that comprise a contact spot, the method comprising the steps of:

[0020] A. Providing a flexible, polymeric film having a first facial side that has a copper metal coating and a second facial side that does not have a metal coating;

[0021] B. Applying a solder-mask to the copper metal coating to define a plurality of discreet radiator traces, each trace without a contact spot, the radiator traces arrayed in a matrix comprising at least two rows;

[0022] C. Applying etch-resist to the copper metal coating to define the contact spot of each radiator trace;

[0023] D. Etching from the film the metal coating not covered by the solder-mask or etch-resist;

[0024] E. Removing the etch-resist from the copper metal coating;

[0025] F. Electrolessly plating the uncovered copper metal coating of the contact spot with a substantially uniform thickness of plating material that comprises at least one of silver, gold and nickel;

[0026] G. Applying a double-sided tape to the second facial side of the polymeric film; and

[0027] H. Cutting the polymeric film and double-sided tape to form strips each of which includes at least one row of radiators.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] Embodiments of the invention are disclosed with reference to the accompanying drawings and are for illustrative purposes only. The invention is not limited in its application to the details of construction or the arrangement of the components illustrated in the drawings. The invention is capable of other embodiments or of being practiced or carried out in other various ways. Like reference numerals are used to indicate like components.

[0029] FIG. **1** is an exemplary flow diagram of a method of manufacturing radiators on a substrate.

[0030] FIG. **2**A is a top view of a substrate with a metal coating.

[0031] FIG. **2**B is a cross-sectional view of FIG. **2**A at line A-A.

[0032] FIG. **3**A is a schematic view of the substrate of FIG. **2**A with multiple solder-masks on the metal coating defining the traces of exemplary radiators.

[0033] FIG. **3**B is a close-up view of FIG. **3**A.

[0034] FIG. **3**C is a cross-sectional view of FIG. **3**B at line B-B.

[0035] FIG. **4**A is a schematic view of FIG. **3**A with etch-resist applied to the metal coating to define the contact spot of each trace.

[0036] FIG. **4**B is a close-up view of FIG. **4**A.

[0037] FIG. **4**C is a cross-sectional view of FIG. **4**B at line C-C.

[0038] FIG. **5**A is a schematic view of FIG. **4**A with the uncovered metal coating substantially etched away.

[0039] FIG. **5**B is a close-up view of FIG. **5**A.

[0040] FIG. **5**C a cross-sectional view of FIG. **5**B at line D-D.

[0041] FIG. **6**A is a schematic view of FIG. **5**A with the etch-resist removed from the contact spots.

[0042] FIG. **6**B is a close-up view of FIG. **6**A.

[0043] FIG. **6**C is a cross-sectional view of FIG. **6**B at line E-E.

[0044] FIG. **6**D is a close-up perspective view of FIG. **6**B at F-F.

[0045] FIG. **7**A is a schematic view of FIG. **6**A with the uncovered metal coating plated with a plating material.

[0046] FIG. **7**B is a close-up view of FIG. **7**A.

[0047] FIG. **7**C is a cross-sectional view of FIG. **7**B at line G-G.

[0048] FIG. **7**D is a side view of **7**B at line H-H depicting the edge surface of the trace and the addition of an adhesive.

[0049] FIG. **7**E is a close-up perspective view of **7**B at **1-1**.

[0050] FIG. **8**A is a schematic view of FIG. **7** showing exemplary strip, hole, and radiator cut marks.

[0051] FIG. **8**B is a close-up view of FIG. **8**A.

[0052] FIG. **9** is an exploded view of FIG. **8**B.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0053] The numerical ranges in this disclosure are approximate, and thus may include values outside of the range unless otherwise indicated. Numerical ranges include all values from and including the lower and the upper values, in increments of one unit. As an example, if a compositional, physical or other property, such as, for example, substrate thickness, metal coating thickness, etc. is from 1 to 100, it is intended that all individual values, such as 1, 2.6, 3, etc., and sub ranges, such as 10 to 30, 40 to 60, etc., are expressly enumerated. In addition, one unit is considered to be 0.0001, 0.001, 0.01 or 0.1, as appropriate. These are only examples of what is specifically intended, and all possible combinations of numerical values between the lowest value and the highest value enumerated, are to be considered to be expressly stated in this disclosure. Numerical ranges are provided within this disclosure for, among other things, the thickness of the substrate and the metal coating.

[0054] "Flexible" and like terms mean capable of being substantially bent with minimal force and without breaking or creasing.

[0055] "Rigid" and like terms mean non-flexible, stiff or unyielding, requiring greater than a minimal force to bend, and likely to break or crease under such bending force.

[0056] "Radiator" and like terms mean an electrical component comprising, among other things, a contact spot, and that is capable of radiating an electromagnetic field in response to Radio Frequency (RF) voltage or current that is applied or induced to it, the radiator being capable of operating as both a transmitter and/or a receiver.

[0057] "Trace" and like terms mean the conductive pathway of an electrical circuit or component.

[0058] "Contact spot" and like terms mean that part of a trace that connects the electrical circuit or component to a source of electrons and/or another electrical circuit or component.

[0059] "Hole" and like terms mean an aperture or passage that extends completely through the substrate and, optionally, the adhesive.

[0060] "Solder-mask" and like terms mean a lacquer-like layer of polymer that provides a protective coating, typically a permanent protective coating, for the metal traces of an electrical circuit, typically a printed electrical circuit. It prevents bridging between conductors thus preventing or reducing short circuits.

[0061] "Etching" and like terms mean the process of removing a portion of unprotected metal coating from the substrate by exposing the unprotected coating to an etching agent, such as an acid, for example ferric chloride in combination with ammonium persulfate.

[0062] "Plating" and like terms mean the deposition of a metal onto a conductive surface, typically another metal.

[0063] "Electroplating" and like terms mean that an ionic metal is supplied with electrons to form a non-ionic coating on a substrate. One common system involves a chemical solution with the ionic form of the metal, an anode (positively charged) which may consist of the metal being plated (a soluble anode) or an insoluble anode (e.g., carbon, platinum, titanium, lead, or steel), and finally, a cathode (negatively charged) where electrons are supplied to produce a film of non-ionic metal.

[0064] "Electroless plating", "chemical plating", "autocatalytic plating"and like terms mean a non-galvanic type of plating method that involves several simultaneous reactions in an aqueous solution which occur without the use of external electrical power. In one embodiment, the reaction is accomplished when hydrogen is released by a reducing agent, e.g., sodium hypophosphite, and oxidized thus producing a negative charge on the surface of a substrate.

[0065] Although the following description of the invention is in the context of a method for manufacturing electrical components, more specifically a radiator from a polymeric film bearing a copper coating on one of its facial sides, and plating at least a portion of the radiator with a plating material comprising silver, the method may be applied to other components utilizing other metal coatings on other substrates and plated with other materials. Various items of equipment that may be used to facilitate the manufacturing process, such as lasers and the like, have been selectively omitted to simplify the drawings.

[0066] FIG. **1** is a flow diagram depicting exemplary method steps **1***a*-**1***i* which are discussed in greater detail below. These method steps may be performed in more than one order, and the method may comprise more or fewer steps.

[0067] FIGS. **2**A and **2**B depict an exemplary substrate, namely polymeric film **2** having first facial side **4** and second facial side **6**, with first facial side **4** having metal coating **8** applied to its surface. In the present embodiment, film **2** is comprised of a flexible material such as polyethylene terephthalate, although other types of polymeric film and substrates may be used. In at least one embodiment, film **2** has a thickness of 40 to 60 microns, typically 50 microns, although other embodiments may differ in thickness. In addition, other embodiments may include a substrate comprised of a rigid material, such as synthetic resin bonded paper or fiberglass, although other rigid materials may be used. Further, although coating **8** in the present embodiment is a copper coating having a thickness of 10 to 30 microns, typically 20 microns, other types of coatings **8**, such as zinc and aluminum, can also be used.

[0068] More particularly, FIG. **2**B is a cross-sectional view of FIG. **2**A at line A-A, depicting coating **8** layered on first facial side **4** of film **2**. Film **2** serves as a base for supporting coating **8**. A circuit trace, such as for a radiator (as seen in FIG. **3**A), is formed from at least a portion of coating **8** and as such, it is affixed or otherwise adhered to film **2**.

[0069] As seen in FIG. **3**A, the covering material is applied to metal coating **8** in the pattern or configuration of a matrix or array of discreet circuit traces **10**. In addition other portions of coating **8** may be covered with the solder-mask to form other markings on the metal coating, e.g., register marks **14**, which can be used as reference points during the manufacturing process. Solder-mask **12** is comprised of a material that is impervious to the chemicals used in both the etching and plating processes and as such, protects the covered metal coating from removal from the substrate. Such materials are well known and commercially available. Further, solder-mask **12** serves as a cost effective material for protecting the trace of the radiator from exposure to various elements that can result in its corrosion and this in turn, obviates the need for the application of an anti-corrosive material that would add to both the cost and time of the manufacturing process. Solder-mask **12** is applied on coating **8** by one or more of various methods, such as screen printing and photo-etching using a flatbed or cylinder screen machine that utilizes a charge coupled device. The covering material can also be applied using a rotary screen or an inkjet.

[0070] Further referencing FIGS. **3**A and **3**B, although the methods described may be used to manufacture a plurality of radiators on film **2**, the methods may also be used to manufacture a single radiator on a single sheet of film. FIG. **3**A depicts a plurality of traces **10** on film **2** in a matrix configuration. In reference to FIG. **3**B, a close-up view of trace **10** is depicted with trace **10** having one or more yet-to-be-formed or proto-contact spots **16**. These contact spots will be defined and spot-plated, as discussed below, and thus this part of metal coating **8** is not covered by solder-mask **12**. FIG. **3**C depicts a cross-sectional view of FIG. **3**B at line B-B, showing film **2**, coating **8**, solder-mask **12** and proto-contact spot **16**.

[0071] Referring to FIGS. **4**A and **4**B, to prevent the removal of coating **8** situated at contact spots **16** during the etching process, etch-resist **18** is applied onto proto-contact spots **16**. Etch-resist is applied similarly to solder-mask **12**. In addition, the application of solder-mask **12** and etch-resist **18** may be performed separately or simultaneously. FIG. **4**C is a cross-sectional view of FIG. **4**B at line C-C depicting etch-resist **18** applied over proto-contact spot **16**.

[0072] Referring to FIGS. **5**A, **5**B and **5**C, after metal coating **8** has been covered by solder-mask **12** and etch-resist **18**, coating **8** is removed from film **2** in an etching process. This process generally results in imperfect edge coating **20** along the solder-mask and etch-resist such that at places the metal extends beyond the solder-mask/etch-resist edge (e.g., a convex extension or bulge extending out from the solder-mask/etch-resist edge, not shown) while at other places metal is removed from beneath the solder-mask/etch-resist edge (e.g., a concave extension or cavity extending beneath the solder-mask/etch-resist edge, also not shown). These edge imperfections are due, in part, to the solder-mask and etch-resist themselves, i.e., their edges are typically not straight and smooth (at least on a microscopic level) and the action of the etching agent will simply follow this edge. In addition the etching agent will, to a limited extent, work its way under the solder-mask and etch-resist until the etching agent is removed from the surface of the metal coating, typically by washing. This edge imperfection and/or loss of metal beneath the solder-mask and etch-resist can diminish the radio frequency performance of the radiator.

[0073] Referring to FIGS. **6**A-**6**D, after traces **10** have been substantially formed by the etching process, etch-resist **18** covering now contact spots **16** is stripped away to expose the remaining coating **8**.

[0074] At this point the edges of traces **10** and contact spots **16** are ready for plating. Contact spots **16** and edge surface **20** are electrolessly plated by contacting them with a plating solution containing plating material **24** that adheres to metal coating **8**. The plating material **24** is typically a metal, more typically at least one of gold, silver and nickel. In one embodiment plating material **24** comprises a metal that has a high density that effectively blocks the oxidation of the metal, e.g., copper, that is located beneath it while maintaining a high level of conductivity, such as the silver used in the ESM-200 autocatalytic electroless silver-plating process by Polymer

Kompositer of Gothenburg, Sweden. This particular plating process provides a dense silver coating that is relatively uniform in thickness across the surface of which it is applied. The thickness of the plated material will vary with the electrical component although the thickness is typically at least 0.1 micron, more typically 0.2 to 3 microns, particularly for microwave applications. In one embodiment, the thickness of the plated material is not greater than 2 microns.

[0075] As shown in FIGS. **7**A-**7**E, after sufficient exposure plating material **24** adheres to contact spots **16** and edge surface **20**. The spot-plating protects contact spots **16** from corrosion while retaining their electrical conductivity. Further, the plating protects edge surface **20** from corrosion and fills in its imperfections with plating material **24**. As the electrical losses increase at high frequencies when a current is forced to flow over irregularities, smoothing out the irregularities along edge surface **20** improves the RF properties of the radiator (i.e. increased transmitting capabilities, a lower loss value and potentially lower power consumption). In at least one embodiment, plating material **24** is adhered to at least one of contact spots **16** and edge surfaces **20** by the use of an electroplating process.

[0076] Upon completion of plating, an adhesive, such as double-sided tape **26**, is applied to second side **6** of film **2**, as seen in FIGS. **7**C-**7**E. Tape **26** includes first facial side **28** which is applied to film **2** and second facial side **32** that remains protected by backing **36**. After tape **26** has been applied, various cuts are performed. Referring to FIGS. **8**A and **8**B, the areas to be cut are represented by hole cut marks **30**, radiator cut marks **34**, and strip cut marks **38**. These cut marks represent a predefined cutting route that is programmed into a controller that operates a laser that will perform the cuts as described below. Register marks **14** may serve as a reference guide for the laser. In addition, an automated or manually operated die tool may be configured to provide the necessary cuts. Further, the cut marks may be printed on film **2** to serve as a visual guide for an automated or non-automated cutting tool.

[0077] Hole cut marks **30** identify the locations where holes are to be cut. Radiator cut marks **34** identify a template for the radiator. Radiator cut marks **34** are not through-cut, but rather kiss-cut (i.e. the cut is made through film **2** and substantially through tape **26**, although backing **36** of the tape **26** is not cut). The kiss-cut allows for the radiators to be maintained in a sheet or roll form until removal is desired. Maintaining the radiators on a sheet or roll provides a convenient form for use in an automated radiator installation process. FIG. **9** provides an exploded view of the radiator after the hole cut marks **30** and radiator cut marks **34** have been completed. In addition, referring again to FIGS. **8**A and **8**B, strip cut marks **38** may be through-cut to separate the radiators on film **2** into strips containing one or more radiators. At this point the radiator may be adhered to a molded plastic carrier (not shown) using tape **26**, to form an antenna (not shown). The carrier and the radiator may then be mounted on a printed circuit board or directly to a portion of one of various types of devices, such as a cellular telephone, a laptop computer, and a Global Positioning System (GPS).

[0078] In the present embodiment, a laser (not shown) such as a CO_2 laser or a UV laser, is the primary or sole cutting tool. The manufacturing process described provides a matrix of radiators that is suitable for laser cutting. As coating **8** does not extend beyond a perimeter of each radiator, superfluous coating, such as robber bars or contact strips that would interfere with the use of a laser, has been eliminated. Further, the use of a laser allows the locations of cuts identified by cut marks **30**, **34**, **38** to be modified merely by adjusting the cutting route programmed into a laser controller. This provides substantial versatility in the manufacturing process as it precludes the need for fixed die tools in the cutting process. The use of fixed die tools requires a new die tool to be manufactured having a new configuration each time the cutting parameters change.

[0079] Further, strip cut marks **38** may be cut using a laser as no robber bars or contact strip exist. Alternatively, a non-laser cutting tool, such as a cutting blade that is adjustable based on the desired strip size may be used. The non-laser cutting tool provides a sufficient cutting function for strip cut marks **38** as the strip cut is generally linear and may be accommodated by a single tool for various strip sizes.

[0080] The present invention is not limited to the embodiments and illustrations, but includes modified forms of those embodiments including portions of the embodiments and combinations of elements of different embodiments as come within the scope of the following claims.

We claim:

1. A method of manufacturing an electrical component that comprises a trace that comprises a contact spot, the method comprising the steps of:

A. Providing a substrate having a first facial side that has a metal coating and a second facial side that does not have a metal coating;

B. Applying a covering material that is impervious to etching and plating to the metal coating to define the trace of the electrical component except for the contact spot;

C. Applying etch-resist to the metal coating to define the contact spot of the trace;

D. Etching from the substrate the metal coating not covered by the covering material or etch-resist;

E. Removing the etch-resist from the metal coating; and

F. Plating the uncovered metal coating with a plating material comprising at least one of silver, gold and nickel.

2. The method of claim **1** in which the plating is electroless plating.

3. The method of claim **2** in which the electroless plating is autocatalytic electroless silver plating.

4. The method of claim **2** in which the covering material and etch-resist is applied to the metal coating by at least one of screen printing and photo-etching.

5. The method of claim **4** comprising the further step of applying an adhesive to the second side of the substrate.

6. The method of claim **5** comprising the further step of cutting at least the substrate with a laser after the uncovered metal coating is plated.

7. The method of claim **6** in which the covering material is applied to the metal coating of the substrate to define a plurality of traces arrayed in a matrix comprising at least two rows.

8. The method of claim **7** in which the substrate is cut into strips with each strip including at least one electrical component.

9. The method of claim **7** in which the substrate is flexible.

10. The method of claim **9** in which the electrical component is a radiator.

11. The method of claim **10** in which the substrate is a polymeric film.

12. The method of claim **11** in which the substrate is a polyethylene terephthalate film, the metal coating is copper, and the plating material is applied in a substantially uniform thickness to the uncovered metal coating.

13. The method of claim **12** in which the film has a thickness of 40 to 60 microns, the metal coating has a thickness of 10 to 30 microns, and the thickness of the plated material is at least 0.1 micron.

14. The method of claim **13** in which the adhesive is a double-sided tape.

15. The method of claim **14** in which the cutting of the film with a laser includes cutting holes through the film and substrate.

16. The method of claim **15** in which the thickness of the plated material is 0.2 to 3 microns.

17. The method of claim **2** in which the substrate is rigid.

18. A method of manufacturing radiators on a polymeric film, the radiators comprising a trace that comprises a contact spot, the method comprising the steps of:

A. Providing a flexible, polymeric film having a first facial side that has a copper metal coating and a second facial side that does not have a metal coating;

B. Applying a solder-mask to the copper metal coating to define a plurality of discreet radiator traces, each trace without a contact spot, the radiator traces arrayed in a matrix comprising at least two rows;

C. Applying etch-resist to the copper metal coating to define the contact spot of each radiator trace;

D. Etching from the film the metal coating not covered by the solder-mask or etch-resist;

E. Removing the etch-resist from the copper metal coating;

F. Electrolessly plating the uncovered copper metal coating of the contact spot with a substantially uniform thickness of plating material that comprises at least one of silver, gold and nickel;

G. Applying a double-sided tape to the second facial side of the polymeric film; and

H. Cutting the polymeric film and double-sided tape to form strips each of which includes at least one row of radiators.

19. The method of claim **18** in which the polymeric film is a polyethylene terephthalate film that has a thickness of 40 to 60 microns, the copper metal coating has a thickness of 10 to 30 microns, and the thickness of the plated material is not greater than 2 microns.

20. The method of claim **19** in which the plating material comprises silver.

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