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Rackus et al.

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[45] **June 4, 1974**

[54] **NONUNIFORMLY TREATING ARTICLES AND SUPPORTING THEM THEREFOR**

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[22] Filed: **July 17, 1972**

[21] Appl. No.: **272,539**

Related U.S. Application Data

[60] Continuation-in-part of Ser. No. 263,897, June 19, 1972, abandoned, which is a division of Ser. No. 100,176, Dec. 21, 1970, Pat. No. 3,692,638.

[52] **U.S. Cl.** **134/158,** 134/140, 134/149, 156/345

[51] **Int. Cl.** **B08b 3/08,** B08b 11/02

[58] **Field of Search**.... 134/157, 158, 159, 138–140, 134/149, 141, 153, 162; 156/345

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[57] **ABSTRACT**

In making transistors using lead frames, improved bonds and savings in gold result from plating gold more heavily and in controlled amounts at the ends of the lead frames where wire and semiconductive chip bonds are to be made. To accomplish such nonuniform plating, the lead frames are arranged in a spaced, radial, fan-like manner about an axis to form a cylindrical configuration of the frames. The ends of the frames where bonds are to be made are on the outer periphery of the configuration. The carrier strips, which are located opposite such ends and which are eventually trimmed away, are on the internal portion of the configuration and may be partially masked to reduce gold plating on such strips. A cathode is connected to the lead frames, which are then immersed in a plating bath and revolved about the axis of the frames and within a hollow cylindrical anode spaced midway between two flat anodes. A sparger pumps the bath in a direction substantially perpendicular to the axis of the frames. The frames and cylindrical anode are positioned midway between the top surface of the bath and the bottom of a tank holding the bath. With this arrangement the frames are nonuniformly plated, with more gold being plated on the ends where bonds are to be made than on the carrier strips. Also, each group of three leads of each frame for a single transistor is plated substantially alike. This arrangement of the frames and rotation of them in the bath also results in the plating of a large number of frames using a minimum volume of a tank holding the bath. An increase in plating rates is also achieved.

4 Claims, 7 Drawing Figures

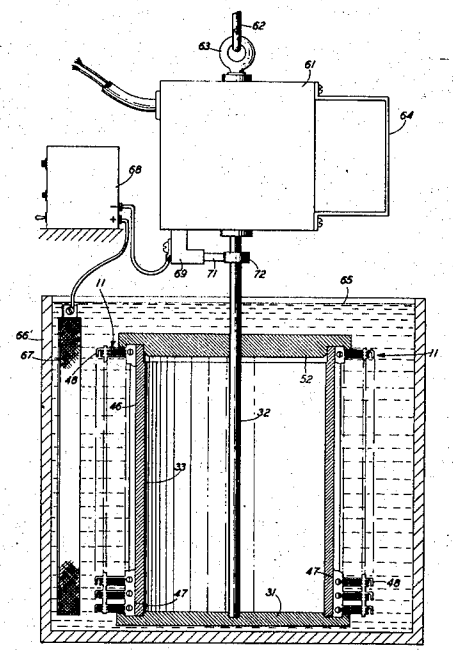


FIG.-1

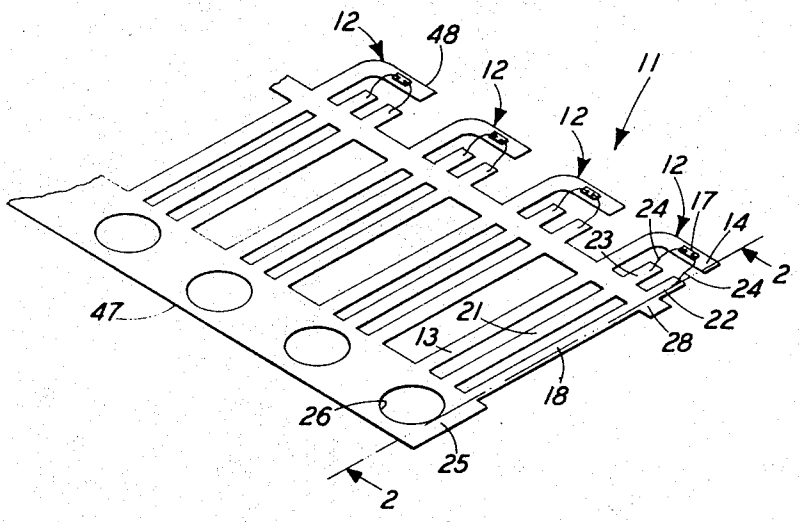
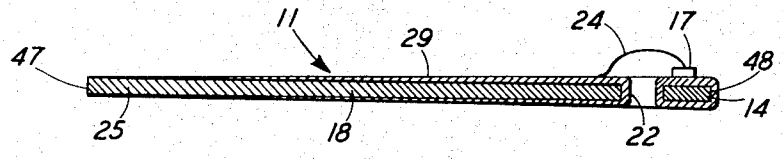

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FIG.-2


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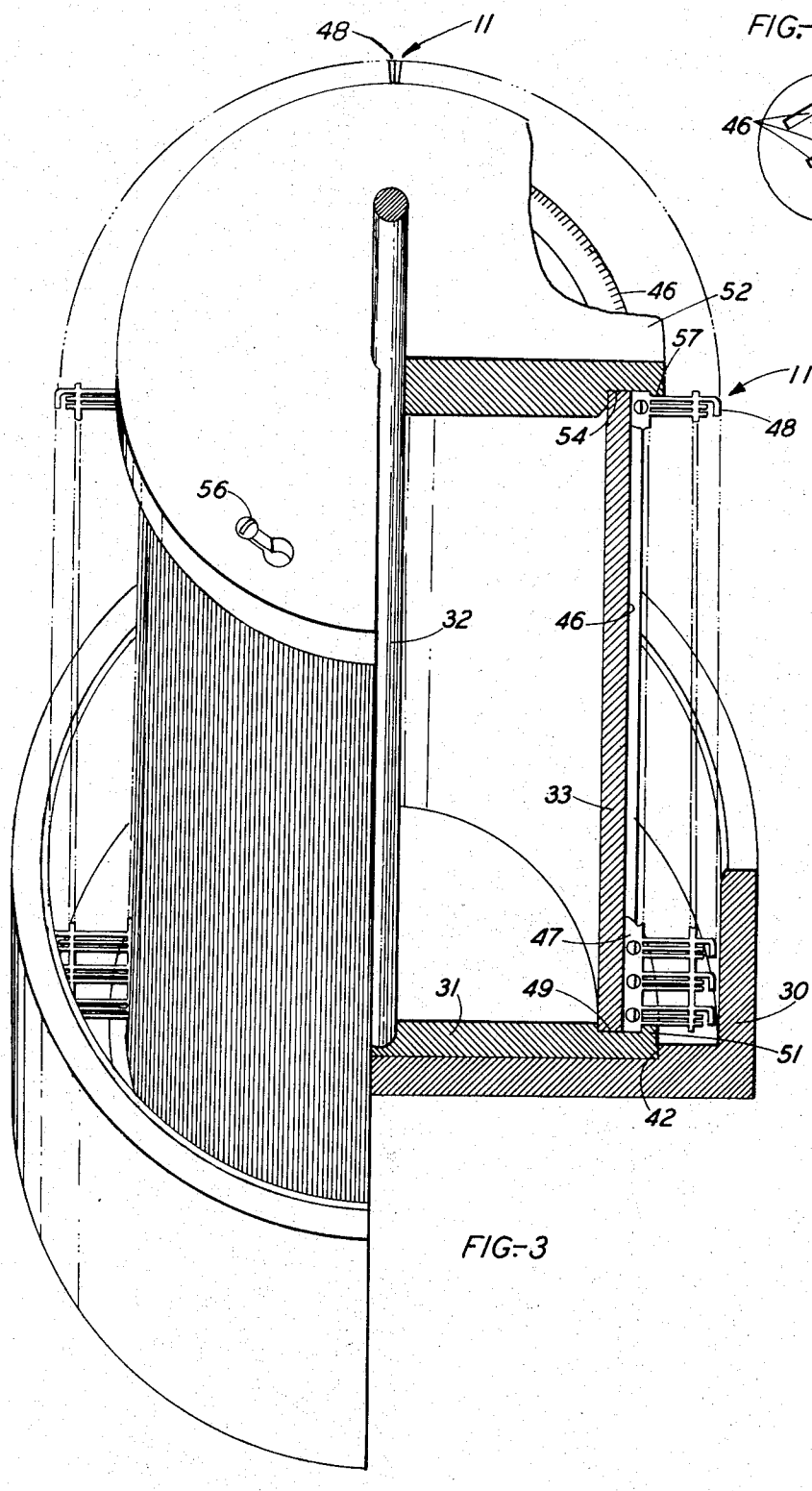


FIG.-3

FIG.-4

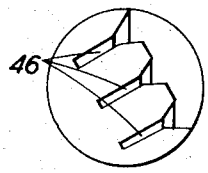


FIG.-5

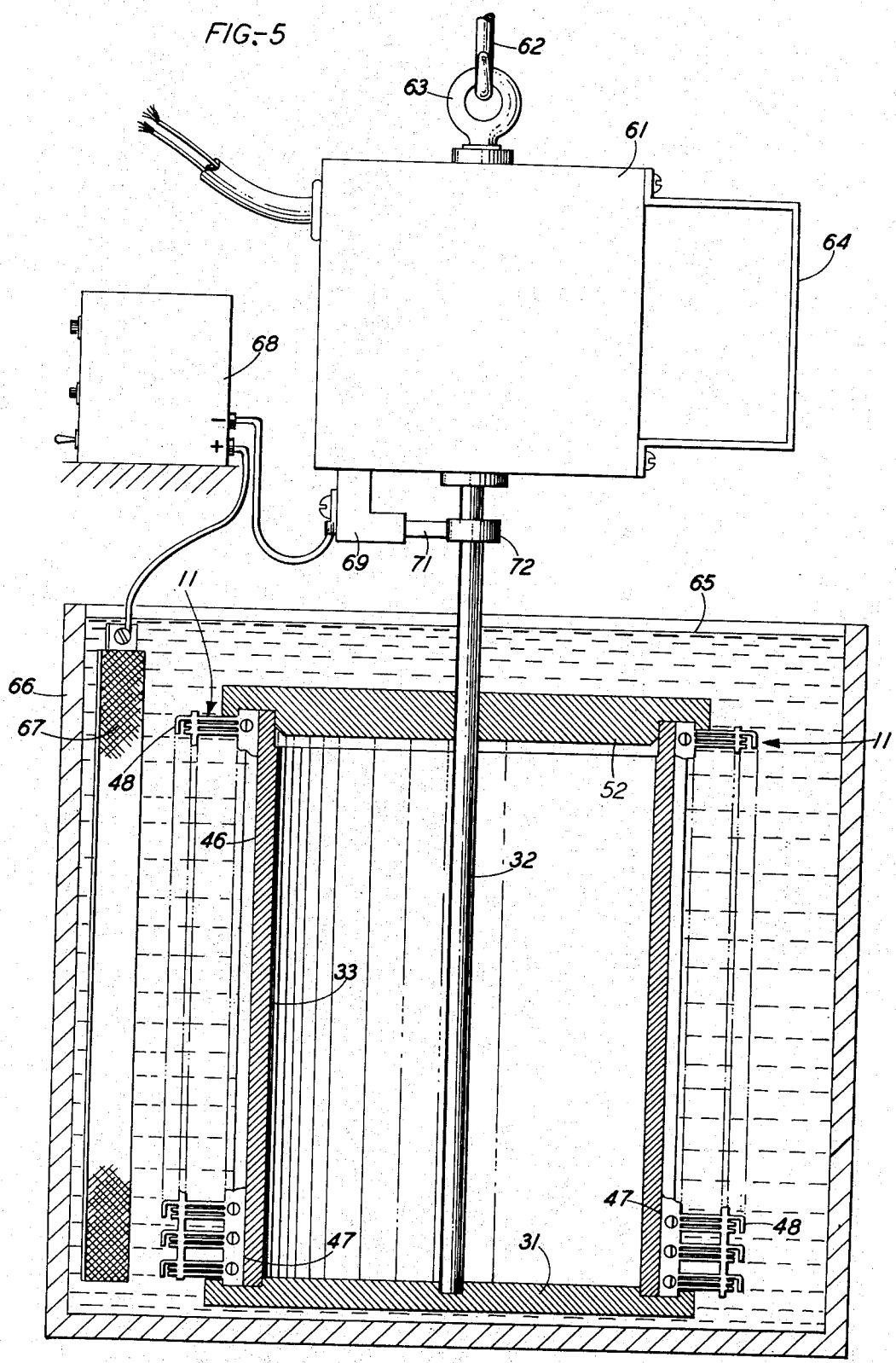
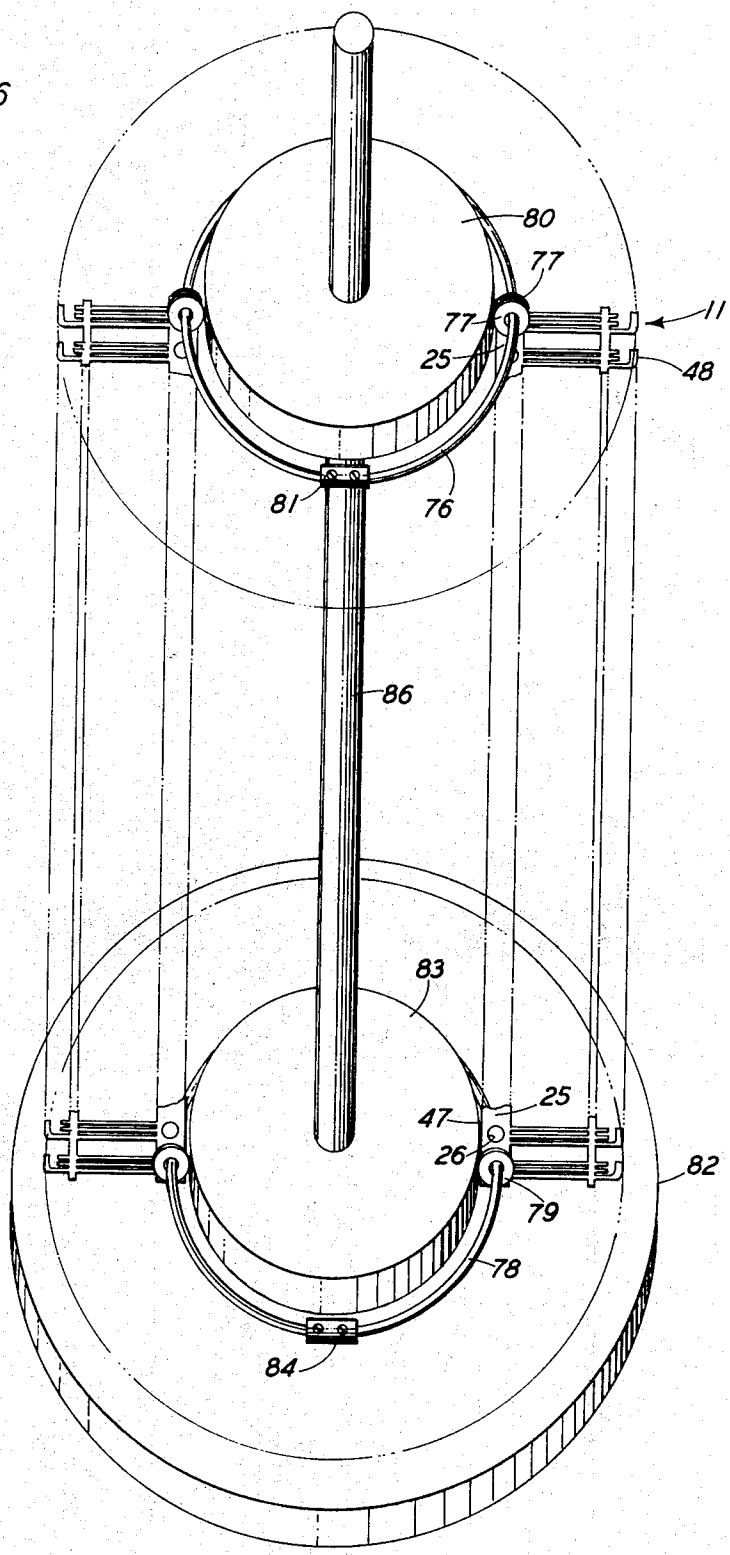


FIG.-6



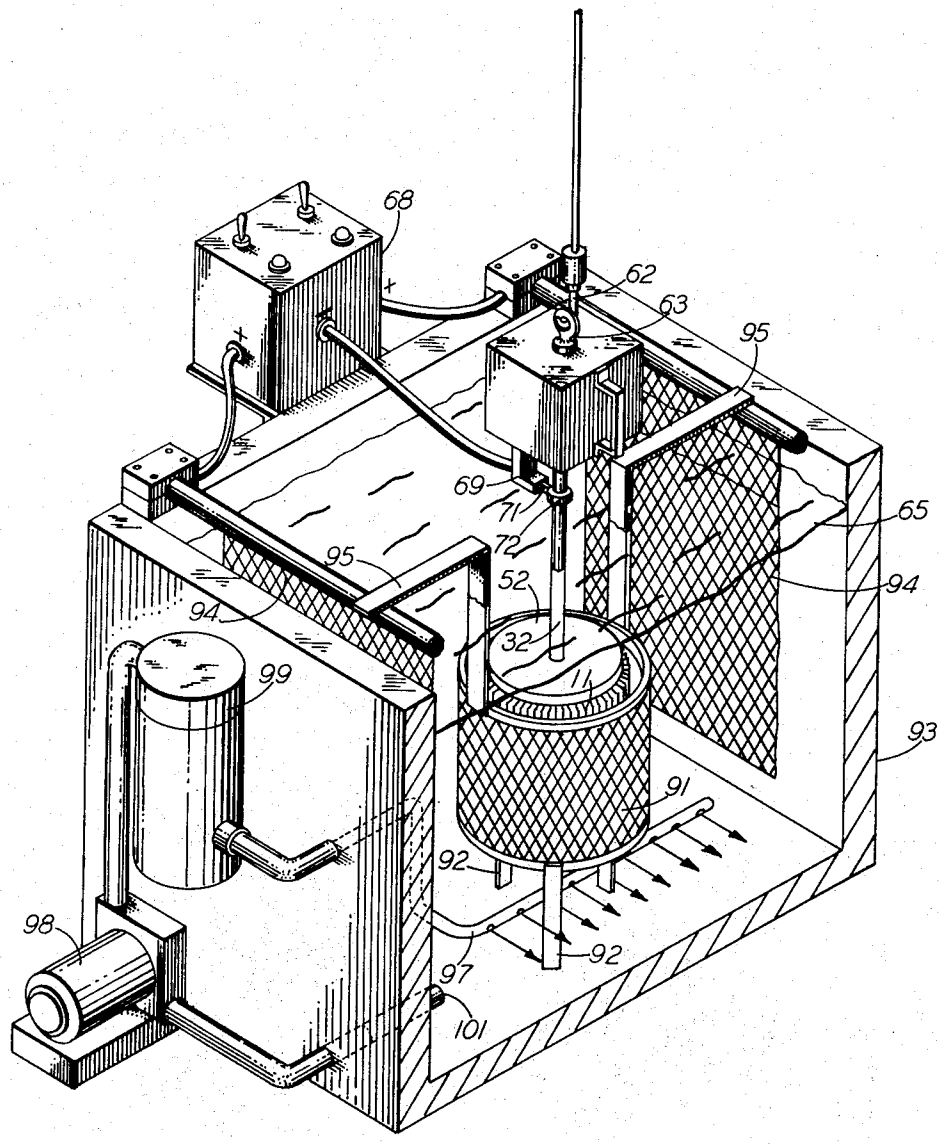


FIG.- 7

NONUNIFORMLY TREATING ARTICLES AND SUPPORTING THEM THEREFOR

CROSS REFERENCE

This application is a continuation-in-part of copending application Ser. No. 263,897, filed June 19, 1972 now abandoned, which is a division of application Ser. No. 100,176, filed Dec. 21, 1970, now U.S. Pat. No. 3,692,638.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to apparatus for nonuniformly treating articles and supporting them therefor, and more particularly, to apparatus for plating a nonuniform layer of a metal on a conductive article.

This invention is suited for use in the manufacture of semiconductive devices such as transistors, diodes, integrated circuits or the like. While this invention is particularly suited for electroplating a nonuniform gold layer on a nickel lead frame for transistors, it is also equally well suited for other chemical, mechanical or combined chemical and mechanical treating applications, such as electroless plating, anodizing, polishing, cleaning or the like, wherein different degrees of interaction by the treating medium and the treated article are desired.

2. Description of the Prior Art

In the manufacture of transistors, leads for the transistors are formed from a lead frame stamped from a sheet of conductive metal such as nickel. Each lead frame has one group of three leads for each transistor. Each group includes one outer lead having a curved end portion upon which a semiconductive chip is bonded, an inner lead having a straight end portion upon which a fine wire extending from the chip is bonded, and another outer lead having another straight end portion upon which another fine wire extending from the chip is bonded.

The individual leads of each frame are joined together by a perforated carrier strip at one end so that the ends of the leads where bonding is to be performed are free of the strip. The leads are also joined together intermediate their ends by a relatively narrow support strip. Both of the strips are severed to separate the individual leads prior to the completion of the ultimate transistor. (See Maguire, Koons and Jarrett, "Plastic Encapsulated Transistors," *The Western Electric Engineer*, pp. 41–51, October, 1970.)

Because an increased and controlled thickness of gold on the free end portions of the leads improves any bonds formed on these ends, it is desirable to have a greater thickness of gold on such ends than on the remainder of the leads. Since chip bonds normally require a greater thickness of gold to obtain good bonds than do wire bonds, it is also desirable that the curved free end portion of the leads have a greater thickness of gold than the straight free ends of the leads. Since the perforated carrier strip is ultimately trimmed away, it is further desirable to have the least thickness of gold on it. While the leads themselves require some gold for thermal protection of the semiconductive chip and for corrosion protection and solderability of the leads, they do not require as much thickness of gold as do the free ends where the chip and wire bonds are to be formed, but require more gold than the carrier strip. Such a nonuniform distribution of gold can result in a very desirable efficient use and substantial savings of gold.

In treating the lead frames by plating or similar techniques, it is also desirable to arrange them so as to treat a maximum number of frames at a time using a minimum volume of a tank holding a treating medium. Such an arrangement minimizes the space required for the treating tank. In addition, it is desirable that the treating time be minimized and that the treating rate be maximized. Further, it is desirable to improve the control over the treating operation.

While it is desirable that the leads and the carrier strip have a nonuniform thickness of gold, it is also desirable that each frame and each group of three leads of each frame be treated substantially alike.

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to provide new and improved apparatus for supporting articles in a treating medium.

Another object of this invention is the provision of apparatus for nonuniformly treating articles.

A further object of this invention is to provide apparatus for nonuniformly plating a layer of a metal on a plurality of conductive articles.

This invention also contemplates apparatus for supporting articles in a treating medium. The apparatus includes a first member having a plurality of slots formed in the outer surface thereof for arranging the articles in a spaced, radial, fan-like manner. The apparatus also includes retaining members that cooperate with the first member for maintaining the articles in the cylindrical configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the present invention may be more clearly understood by reference to the following detailed description and drawings, wherein:

FIG. **1** is a greatly enlarged, fragmentary, perspective view of a lead frame, showing leads joined together by a perforated carrier strip and a relatively narrow support strip, showing semiconductive chips bonded to curved portions of the free ends of outer leads, and showing fine wires extending from the chips to the other free ends of inner and other outer leads;

FIG. **2** is a sectional view taken along line **2—2** of FIG. **1**, showing a nonuniform layer of a metal on the lead frame of FIG. **1**;

FIG. **3** is a perspective view, partly in section, showing a tubular member, having a plurality of spaced parallel slots, positioned within and extending from a loading cup that assists the placing of the frames in the slots to arrange them in a cylindrical configuration;

FIG. **4** is an enlarged view of a portion of FIG. **2**, showing the slots of FIG. **2** in greater detail;

FIG. **5** is a front elevational view, partly in section, of the tubular member of FIG. **3** having a plurality of lead frames mounted in slots formed in its outer peripheral surface and immersed in a bath for nonuniformly electroplating gold on each frame;

FIG. **6** is a perspective view of an alternative embodiment of the present invention showing a plurality of lead frames mounted in a cylindrical configuration by inserting a flexible wire-like member alternately into perforations formed in the carrier strips of the lead frames and into conductive spacing washers; and

FIG. 7 is a perspective view of a preferred arrangement of the tubular member of FIG. 3 with lead frames mounted thereto in a plating tank having a cylindrical anode, a pair of flat anodes and a sparger.

DETAILED DESCRIPTION

LEAD FRAME

Referring now to the drawings and in particular to FIG. 1, a lead frame, designated generally by the numeral **11**, is shown. The frame **11** has a plurality of groups of leads, designated generally by the numeral **12**, one group being associated with each transistor which is ultimately to be fabricated using the lead frame **11**. Each group **12** includes an outer lead **13** having a curved end portion **14** to which a semiconductive chip **17** is bonded. Each group also has another outer lead **18** and an inner lead **21**, both of which have straight end portions **22** and **23** to which fine gold wires **24** extending from the chip **17** are bonded.

Each lead frame **11** includes a carrier strip **25** having perforations **26** therein. The perforated carrier strip **25** joins the individual leads **13, 18** and **21** together at one of their ends so that the opposite end portions **14, 22** and **23** where bonds are to be formed are free. The leads **13, 18** and **21** are joined together intermediate their end portions **14, 22** and **23** by a relatively narrow support strip **28**.

Typically, the lead frame **11** is stamped from a nickel sheet about 10 mils thick. In the prior art a uniform layer of gold of about 0.255 to about 0.315 mils was plated on the nickel lead frame **11**.

In accordance with the present invention, a plurality of articles, such as the lead frame **11** (FIG. **1**), a substantially planar article or the like, is nonuniformly treated. While the treatment may be any of a number of different chemical or mechanical or combined chemical and mechanical treatments, such as electroplating, electroless plating, anodizing, polishing, cleaning or the like, the present invention will be described in connection with electroplating. However, it is to be understood that treatments other than electroplating are within the spirit and scope of this invention.

More specifically, a nonuniform layer **29** (FIG. **2**) of a metal, such as gold or the like, is electroplated on the lead frame **11** (FIGS. **1** and **2**) so that the layer **29** has the least thickness on the carrier strip **25**, a greater thickness on the leads **13, 18** and **21**, a still greater thickness at the straight free end portions **22** and **23** where wire bonding is to be performed, and the greatest thickness at the curved free end portion **14** where chip bonding is to be performed.

LOADING

In carrying out the present invention, into a cup **30** (FIG. **3**) there is placed an assembly including a base **31**, a rotatable shaft **32** fixed to and extending from the top side of the base **31** and a hollow tubular member **33** with its bottom end also fixed to the top side of the base **31**. The placing of this assembly in the cup **30** positions the bottom side of the base **31** in a central depression **42** in the cup **30** and extends the shaft **32** and the tubular member **33** from the cup **30** and beyond its side walls.

As shown in FIGS. **3** and **4**, the hollow tubular member **33** has a plurality of spaced slots **46** formed in its outer surface that are parallel to each other, and to the shaft **32** and the axis of the member **33**. The bottom ends of the slots **46** are closed by an annular indentation **49** formed in the top side of the base **31**.

Typically, the slots **46** have a width of about 15 to 20 mils so that they easily receive the lead frames **11** with a thickness of about 10 mils. The inner side portions **47** (FIGS. **1** and **3**) of a plurality of lead frames **11** are individually placed in the slots **46**. By so placing these frames **11**, they are arranged in a substantially radial, fan-like manner and in a hollow cylindrical configuration, as shown in FIG. **3**. In this configuration the outer side portions **48** of the frames **11** are located on the outer periphery of the configuration and are spaced more from each other than the inner side portions **47**, as is apparent from FIG. **3**.

Since the bottom ends of the slots **46** are enclosed by the annular indentation **49** in the base **31**, the frames **11** are axially retained in the slots **46** to prevent them from dropping out. Also, the frames **11** are laterally retained in the slots **46** by the loading cup **30** and a rim **51** formed by the indentation **49** in the base **31**.

After the frames **11** are loaded in the slots **46**, an insulative capping member **52** (FIG. **3**) having an annular indentation **54** is mounted removably to the top end of the tubular member **33** by conventional securing devices, such as machine screws **56** or the like.

By so mounting the capping member **52**, the top end of the tubular member **33** fits into the annular indentation **54** and closes the top ends of the slots **46** to axially retain the frames **11** in the slots **46**. Also, a rim **57** formed by the indentation **54** laterally retains the frames **11** in the slots **46**. Thus, the combination of the slots **46** in the tubular member **33**, the indentations **49** and **54** in the base **31** and in capping member **52**, and the rims **51** and **57** in the base **31** and in capping member **52** completely support and retain the frames **11** in the cylindrical configuration. Therefore, after the capping member **52** is mounted to the tubular member **33**, the loading cup **30** is no longer necessary to completely support and retain the frames **11** in the cylindrical configuration.

TREATING MEDIUM

Next, the assembly of the base **31**, the shaft **32**, the tubular member **33**, the frames **11**, and the capping member **52** are removed from the loading cup **30** by lifting such assembly by the shaft **32** from the cup **30**. The shaft **32** is then connected to a conventional rotating device, such as a motor **61** (FIG. **5**).

The assembly is next immersed in a treating medium with the shaft **32** extending therefrom by suspending the motor **61** from a fixed hook **62** by an eyelet **63** fastened to the motor **61**. Also, the motor **61** is provided with a handle **64** to facilitate the manipulation of the motor and the assembly connected thereto. While the assembly is shown in FIG. **5** as being suspended vertically by the hook **62** and the eyelet **63**, it should be understood that the assembly may be positioned other than vertically in the treating medium by the use of conventional supporting devices. Such nonvertical positioning does not reduce the effectiveness of the invention.

Illustratively, the present invention is used for electroplating a nonuniform layer of a metal such as gold on a conductive article such as a nickel lead frame **11**. Accordingly, the treating medium is a gold electroplating bath **65** held in a tank **66**. Typically, the bath **65** is an acidic plating solution based on ammonium citrate

and potassium gold cyanide. Also, it may be desirable to preplate the frames **11** in a plating solution based on potassium phosphate with low concentrations of potassium gold cyanide.

In addition to the assembly, the electroplating bath **65** contains an anode **67** of a plating source **68** which also has a cathode **69** connected to the shaft **32** by conventional expedients such as a brush **71** and a slip ring **72.**

In order to deposit the nonuniform layer **29** (FIG. **2**) of gold on the lead frames **11** in accordance with the present invention, the motor **61** (FIG. **5**) is energized to revolve the lead frames **11** past the anode **67.** The power source **68** is then activated to pass current from such source **68** to the anode **67,** the bath **65,** the lead frames **11,** the walls of the slots **46** of the tubular member **33,** the remaining structure of the tubular member **33,** the base **31,** the shaft **32,** the slip ring **72,** the brush **71** to the cathode **69** and back to the source **68.**

By revolving the frames **11** in the bath **65** past the anode **67** and activating the power source **68,** gold is plated from the bath **65** onto the lead frames **11** to form the nonuniform gold layer **29** (FIG. **2**) thereon. The gold layer **29** has its greatest thickness at the outer side portions **48** of the lead frames **11,** which include the curved end portion **14** and the straight end portions **22** and **23,** and has its least thickness at the inner side portions **47** of the frames **11,** which include the perforated carrier strip **25.** Further, the layer **29** has a thickness on the leads **13, 18** and **21** greater than that on the carrier strip **25,** a still greater thickness on the straight end portions **22** and **23** where the wires **24** and **25** are to be bonded, and its greatest thickness on the curved end portion **14** where the chip **17** is to be bonded.

The gold layer **29** is thicker at the outer side portions **48** of the frames **11** than at the inner side portions **47** of the frames **11,** because, it is believed there is a greater interaction of the portions **48** with the plating bath **65** than there is of the portions **47** with such bath **65.** More specifically, it is believed that the layer **29** is thicker at the portions **48** than at the portions **47** because the portions **48** have the greatest velocity through the plating bath **65,** are spaced further apart and are exposed to a greater undepleted amount of the bath **65.** Also, the portions **48** are closer to the anode **64** than the portions **47** when maximum plating occurs. (See the lefthand side of FIG. **5.**) Further, because the portions **47** are located in the slots **46,** these portions **47** are exposed to a smaller amount of the undepleted bath **65** and the slots **46,** tend to partially mask the portions **47.** This aids in reducing the thickness of the gold layer **29** on the portions **47.**

Typically, the thickness of the nonuniform gold layer **29** on the frames **11** varies linearly with distance from approximately 0.300 mils at the curved end portion **14** decreasing to approximately 0.060 mils at the carrier strip **25.** Such thickness of the layer **29** has been achieved with a plating current of about 30 amps and a rotational speed of 50 rpm. The degree to which the thickness of the deposited gold layer is nonuniform is controlled by such factors as the rotational speed of the frames in the bath **65,** the spacing of the frames **11,** the plating current, and the composition of the plating bath.

By plating the lead frames **11** in accordance with the present invention, substantial savings in gold result and at the same time adequate amounts of gold are plated on the curved end portion **14** of the lead **13** for making good chip bonds and on the straight end portions **22** and **23** of the leads **18** and **21** for making good wire bonds. Also, by arranging the lead frames **11** in the cylindrical configuration a large number of frames **11** can be simultaneously plated using a small-volume tank holding the plating bath. In addition, the plating time can be decreased over prior art techniques and at the same time the treating rate and control over the treating operation is increased.

To prevent gold from being plated from the bath **65** on the shaft **32,** the base **31,** and the tubular member **33,** which are electrically conductive; these element **32, 31** and **33** are completely coated with a nonconductive film, such as that sold under the trademark "Kynar," by Pennwalt. However, the walls of the slots **46** which must make electrical contact with the frames **11** to plate them are not coated. The shaft **32** is also coated with the film except where the slip ring **72** is attached. The capping member **52** is made of an electrically insulative material and therefore, no gold is plated from the bath on it.

The walls of the slots **46** receive a minimum thickness of plated gold, since the frame **11** are inserted in the slots **46** exposing only a small amount of the walls of the slots **46** to the plating bath **65,** since the slots **46** are positioned relatively far away from the anode **64,** and since the slots **46** receive a relatively low velocity through the bath **65.** After being used numerous times to plate large quantities of frames **11,** any gold plated on the walls of the slots **46** can be chemically stripped therefrom.

ALTERNATIVE PLATING BATH ARRANGEMENT WITH CYLINDRICAL ANODE AND SPARGER

Instead of using the plating bath arrangement of FIG. **5,** that of FIG. **7** may be used to nonuniformly plate the lead frames **11.** The arrangement of FIG. **7** has the additional advantage of plating each group **12** of each frame **11** with greater uniformity from group to group than is achievable with the arrangement of FIG. **5.**

Referring now to FIG. **7,** a hollow cylindrical anode **91** is shown supported on three equally spaced legs **92.** These legs **92** are positioned on the bottom of a tank **93** that holds the plating bath **65.** The tubular member **33** with the frames **11** mounted in the slots **46** thereof (as shown in FIGS. **3** and **5**) and with the capping member **52** mounted on the tubular member **33** is centrally positioned within the anode **91,** as shown in FIG. **7.** The anode **91** is positioned substantially midway between the upper surface of the bath **65** and the bottom of the tank **93** and substantially midway between a pair of flat anodes **94.** The anode **91** is also electrically connected to these anodes **94** by bars **95.** The anodes **94** are, in turn, connected to the positive terminal of the power supply **68.** As in the arrangement of FIG. **5,** the cathode **69** of the power supply **68** is connected to the frames **11** by way of the brush **71** and slip ring **72.**

Also positioned on the bottom of the tank **93** is a sparger **97** through which a portion of the bath **65** is forced by a pump **98** after it has been drawn from an orifice **101** and passed through a filter **99.** The direction of flow of the effluent from the sparger **97** is substantially perpendicular to the shaft **32.**

ALTERNATIVE FRAME SUPPORTING ARRANGEMENT

An alternative frame supporting arrangement of the invention is shown in FIG. 6. More specifically, the lead frames 11 are formed in a hollow cylindrical configuration for immersion in the plating bath 65 by first inserting a wire-like member 76 alternately into the uppermost perforations 26 of the carrier strips 25 of the lead frames 11 and then into a plurality of conductive washers 77 spaced from each other by the frames 11.

Also, another wire-like member 78 is inserted alternately into the lowermost perforations 26 of the carrier strips 25 and into a plurality of conductive washers 79 spaced from each other by the frames 11, as shown in FIG. 6.

Next, the wire-like members 76 and 78 are formed into a substantially circular configuration. This results in holding the frames 11 in a substantially radial, fan-like manner and in arranging of the lead frames 11 in a hollow cylindrical configuration, as shown in FIG. 6. In this configuration the outer portions 48 of the frames 11 are located on the outer periphery of the configuration and are spaced more from each other than the inner side portions 47, as is apparent from FIG. 6.

An insulative disc element 80 is positioned in the center of the hollow configuration of the lead frames 11 adjacent the uppermost perforations 26 of the carrier strips 25. The ends of the wire-like member 76 are then joined together to force the frames 11 and washers 77 against the element 80, as shown in FIG. 6. Next, the ends of the wire-like member 76 are fastened with a conventional holding expedient 81 to retain the member 76 in a ring-like configuration.

A conductive base plate 82 having a conductive disc element 83 fixed thereto is then positioned beneath the lead frames 11 in electrical contact with them and the washers 79 so that the element 83 is in the center of the cylindrical configuration, as shown in FIG. 6. The ends of the wire-like member 78 are next joined together to force the frames 11 and the washers 79 against the disc element 83. The ends of the wire-like member 78 are then fastened with a conventional holding expedient 84.

A conductive rotatable shaft 86 is connected through the disc element 80 to the disc element 83. The lead frames 11 joined in a cylindrical configuration by the wire-like members 76 and 78 along with the shaft 86, the base plate 82, and the disc element 83 are immersed in the plating bath 65 (FIG. 5 or 7.) The cathode 69 is appropriately connected to the shaft 86 and the frames 11 are revolved by the motor 61 past the anode 67 to plate gold from the bath 65 on the frames 11 in the same way that gold was plated on the frames 11 in the embodiment of FIG. 5.

It is to be understood that the above-described arrangements are simply illustrative of the application of the principles of this invention. Numerous other arrangements may be readily devised by those skilled in the art which will embody the principles of the invention and fall within its spirit and scope.

What is claimed is:

1. An apparatus for treating planar articles, which comprises:

a member having a plurality of slots formed in the outer surface thereof for loosely receiving the planar articles with portions thereof extending out of the slots and being external relative to the surface of said member, and for arranging such articles in a spaced, radial, fan-like manner about the axis of said member, such axis lying in the planes of the articles for partially masking the inner side portions of the articles;

means cooperating with the member for retaining the articles in said manner;

means for positioning the articles in a treating medium; and

means for moving the articles positioned in the treating medium about the axis to increase the interaction of the outer side portions of the articles with the medium to nonuniformly treat the articles.

2. The apparatus of claim 1, wherein the outer surface of the member is convex.

3. An apparatus for treating planar articles, which comprises:

means for loosely receiving the planar articles and for arranging said articles in a spaced, radial, fan-like manner about an axis with the axis lying in the planes of the articles, for partially masking the inner side portions of the articles and for spacing the articles from each other;

means, cooperating with the receiving and arranging means, for retaining the articles in said manner;

means for positioning the articles in a treating medium; and

means for moving the articles positioned in the heating medium about the axis to increase the interaction of the outer side portions of the articles with the medium to nonuniformly treat the articles.

4. The apparatus of claim 3, wherein the retaining means includes a pair of cooperating members having annular channels for holding end portions of the articles.

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