

ELECTROPLATING SYSTEMS AND METHODS

RELATED APPLICATION

[0001] This application claims priority to, and the benefit of, U.S. Application No. 18/341,958, filed June 27, 2023, which is incorporated by reference in its entirety herein.

TECHNICAL FIELD

[0002] This description relates to electroplating, such as electroplating of semiconductor device assemblies.

BACKGROUND

[0003] Electrochemical processes, such as electroplating, can be used to plate metal surfaces (e.g., exposed copper surfaces) of semiconductor device assemblies (device assemblies, assemblies, etc.), such as exposed metal surfaces of a leadframe, metallic seed layers on a substrate, direct-bonded metal layers on a substrate, etc. For instance, such processes can be used to perform tin plating (or plating with other metals), where such plating can prevent corrosion (e.g., oxidation) of corresponding metal surfaces, such as copper, as well as improve solderability of metal surfaces of a semiconductor device assembly. Prior electroplating approaches can have certain drawbacks, however, such as non-uniform plating thickness, where a plating thickness for metal surfaces on one side of an assembly is undesirably thicker than a plating thickness for metal surfaces on an opposite side of the assembly. Such thicker plating can result in leakage and or electrical shorts (e.g., between signal pins or pads and/or power supply pins and/or terminals, etc.) due to excess plating material creating undesired conduction pathways. Also, such prior approaches can increase overall operating and/or product costs due to consumption of excess plating material.

SUMMARY

[0004] In a general aspect, an electroplating system includes a vessel, an electrolytic plating solution in the vessel, a cathode terminal, first and second anode terminals, and first and second variable power supplies. The cathode terminal is configured to electrically connect with a workpiece that is submerged in the electrolytic plating solution. The first anode terminal is in the electrolytic plating

solution on a first side of the workpiece. The second anode terminal is in the electrolytic plating solution on a second side of the workpiece opposite the first side. The first variable power supply is coupled between the cathode terminal and the first anode terminal. The second variable power supply is coupled between the cathode terminal and the second anode terminal.

[0005] Implementations can include one or more of the following features, alone or in combination. For example, the first variable power supply can include a first variable voltage power supply, and the second variable power supply can include a second variable voltage power supply.

[0006] The first variable power supply can include a first variable current power supply, and the second variable power supply can include a second variable current power supply.

[0007] The first anode terminal and the second anode terminal can each include a solid plating material that is soluble in the electrolytic plating solution.

[0008] The electrolytic plating solution can include methane sulfonic acid (MSA) and a liquid plating material.

[0009] The electroplating system can include a third anode terminal in the electrolytic plating solution on the first side of the workpiece, and a fourth anode terminal in the electrolytic plating solution on the second side of the workpiece. The electroplating system can include a third variable power supply that is coupled between the cathode terminal and the third anode terminal, and a fourth variable power supply that is coupled between the cathode terminal and the fourth anode terminal.

[0010] The third variable power supply can include a first variable voltage power supply, and the fourth variable power supply can include a second variable voltage power supply.

[0011] The third variable power supply can include a first variable current power supply, and the fourth variable power supply can include a second variable current power supply.

[0012] The workpiece can be a strip of block molded semiconductor device assemblies.

[0013] In another general aspect, a method includes electrically coupling a workpiece with a common cathode terminal of an electroplating system and

submerging the workpiece in an electrolytic plating solution. The method further includes supplying, from a first anode terminal submerged in the electrolytic plating solution, a first plating current for electroplating at least one plateable surface on a first side of the workpiece. The method further includes supplying, from a second anode terminal submerged in the electrolytic plating solution, a second plating current for electroplating at least one plateable surface on a second side of the workpiece. The second plating current is different than the first plating current, and the second side of the workpiece is opposite the first side of the workpiece.

[0014] Implementations can include one or more of the following features, alone or in combination. For example, the workpiece can be a strip of block molded semiconductor device assemblies.

[0015] The first plating current can be based on an area of the at least one plateable surface on the first side of the workpiece. The second plating current can be based on an area of the at least one plateable surface on the second side of the workpiece.

[0016] The first plating current can be used for plating a first portion of the at least one plateable surface on the first side of the workpiece, and the second plating current can be used for plating a first portion of the at least one plateable surface on the second side of the workpiece. The method can include supplying, from a third anode terminal submerged in the electrolytic plating solution, a third plating current for electroplating a second portion of the at least one plateable surface on the first side of the workpiece. The method can also include supplying, from a fourth anode terminal submerged in the electrolytic plating solution, a fourth plating current for electroplating a second portion of the at least one plateable surface on the second side of the workpiece.

[0017] The third plating current can be different than the first plating current, and the fourth plating current can be different than the second plating current.

[0018] The third plating current can be equal to the first plating current, and the fourth plating current can be equal to the second plating current.

[0019] The third plating current can be equal to the first plating current, and the fourth plating current can be different than the second plating current.

[0020] In another general aspect, an electroplating system includes a vessel, an electrolytic plating solution in the vessel including a liquid plating material, a

common cathode terminal, a first anode terminal, a second anode terminal, a third anode terminal, a fourth anode terminal, a first variable power supply, a second variable power supply, a third variable power supply, and a fourth variable power supply.

[0021] The common cathode terminal is configured to electrically connect with a workpiece that is submerged in the electrolytic plating solution. The first and second anode terminals are in the electrolytic plating solution on a first side of the workpiece. The third anode terminal and fourth anode terminals are in the electrolytic plating solution on a second side of the workpiece opposite the first side. The first variable power supply is coupled between the common cathode terminal and the first anode terminal. The second variable power supply is coupled between the common cathode terminal and the second anode terminal. The third variable power supply is coupled between the common cathode terminal and the third anode terminal. The fourth variable power supply is coupled between the common cathode terminal and the fourth anode terminal.

[0022] Implementations can include one or more of the following features, alone or in combination. For example, the first variable power supply can include a first variable voltage power supply. The second variable power supply can include a second variable voltage power supply. The third variable power supply can include a third variable voltage power supply. The fourth variable power supply can include a fourth variable voltage power supply.

[0023] The first variable power supply can include a first variable current power supply. The second variable power supply can include a second variable current power supply. The third variable power supply can include a third variable current power supply. The fourth variable power supply can include a fourth variable current power supply.

[0024] The workpiece can be a strip of block molded semiconductor device assemblies.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] FIG. 1 is a diagram schematically illustrating an example electroplating system.

[0026] FIG. 2 is a diagram schematically illustrating another example electroplating system.

[0027] FIG. 3 is a diagram illustrating an example strip of block molded semiconductor device assemblies viewed from a first (e.g., top) side.

[0028] FIG. 4 is a diagram illustrating the strip of block molded semiconductor device assemblies of FIG. 3 viewed from a second (e.g., bottom) side.

[0029] FIG. 5 is a diagram illustrating plated areas (e.g., on a bottom side) of a semiconductor device assembly of the strip of block molded semiconductor device assemblies of FIGs. 3 and 4.

[0030] FIG. 6 is a flowchart illustrating an example method for electroplating.

DETAILED DESCRIPTION

[0031] This disclosure is directed to electroplating systems (plating systems, systems, etc.) and associated methods that address at least some of the drawbacks of previous approaches that were noted above. For instance, plating systems and methods described herein can reduce non-uniformity in plating thicknesses on surfaces (e.g., plateable surfaces) on opposite sides of semiconductor device assemblies, such as strips of block molded semiconductor device assemblies or packages. Such block molded strips can have different plateable surface areas on opposite sides, e.g., a first plateable surface area on a top side of the strip, and a second, different plateable surface area on a bottom side of the strip. Molding compound surfaces, for purposes of this disclosure, are not plateable surfaces.

[0032] In disclosed approaches, separate, variable power supplies (e.g., variable voltage and/or current) can be used to supply respective plating currents for plateable surfaces on each side of a semiconductor assembly (e.g., based on corresponding areas of the respective plateable surfaces), rather than providing a single, fixed plating current, as in prior approaches. For instance, if the respective plateable surfaces have different areas and/or are not symmetric, prior plating approaches can result in undesirably thicker plating on the plateable surfaces on a side of the assembly where an area of the plateable surfaces is relatively smaller area, e.g., as compared with an area of the plateable surfaces on the opposite side.

[0033] In contrast, using example implementations described herein, different plating currents can be provided (e.g., on each side of an assembly) such that equal, or approximately equal, plating current densities (e.g., in amps (A) per decimeter-squared (dm^2)) are used for respectively plating surfaces on each side, e.g., on a top

side and a bottom side, of an assembly, where the respective plateable surfaces are not symmetric and/or have different surface areas.

[0034] Further, example approaches described herein can reduce manufacturing and/or product costs by reducing an amount of plating material used as a result of improved plating thickness uniformity. Additionally, by improving plating uniformity, leakage and/or electrical shorts can be prevented, particularly in assemblies with tight pitches (e.g., small distances between signal pins, signal pads, and/or other plated surfaces), as application of undesired excess plating material causing such leakage and/or shorts can be prevented. Accordingly, as compared with prior approaches, the disclosed implementations can facilitate pitch reduction. Such pitch reduction can, in turn, allow for reducing respective sizes of semiconductor device assemblies, which can achieve additional operational and/or product cost savings as a result, such as reduced material costs.

[0035] FIG. 1 is a diagram schematically illustrating an example electroplating system 100. The electroplating system 100 includes a vessel 105 in which an electrolytic plating solution 110 is disposed. In some implementations, the electrolytic plating solution 110 can include methane sulfonic acid (MSA) or equivalent electrolytic solution (such as nickel sulfamate or copper sulfate) and a liquid metal solution, where the liquid metal solution includes a metal, e.g., a liquid plating metal, such as liquid tin, that is used to plateable surfaces, such as exposed metal surfaces, of a workpiece 125 that are submerged, e.g., disposed, in the electrolytic plating solution 110. In some implementations, the electrolytic plating solution 110 can include one or more additives to facilitate efficient electroplating. Other surface of the workpiece 125 disposed in the electrolytic plating solution 110 may be non-plateable, such as molding compound surfaces.

[0036] As shown in FIG. 1, the electroplating system 100 includes a sparger 115 that is disposed within the electrolytic plating solution 110 in the vessel 105. In some implementations, a position of the sparger 115 within the vessel 105 can be adjusted, e.g., in the view of FIG. 1, vertically adjusted based on a size of the workpiece 125 being plated. As indicated by the arrows 115a in FIG. 1, the sparger 115 can generate a fluidic flow within the electrolytic plating solution 110. This fluidic flow can agitate the electrolytic plating solution 110 (e.g., to maintain homogeneity of the electrolytic plating solution 110 and/or to facilitate plating

efficiency). In some implementations, the sparger 115 can create a laminar flow of the electrolytic plating solution 110 over the workpiece 125.

[0037] The electroplating system 100 of FIG. 1 includes a cathode terminal 120. The cathode terminal 120 includes a clip 120a that is used to physically and electrically couple the cathode terminal 120 with the workpiece 125, e.g., to electrically couple the cathode terminal 120 with surfaces of the workpiece 125 to be plated, such as a leadframe strip including a plurality of semiconductor device assemblies, e.g., a strip of block molded device assemblies. While a single clip (clip 120a) is shown in FIG. 1, in some implementations the cathode terminal 120 can include a plurality of clips for electrically coupling to the workpiece 125, and for positioning the workpiece 125 within the electrolytic plating solution 110.

[0038] In the example of FIG. 1, the electroplating system 100 also includes an anode terminal 130 disposed on a first side of the workpiece 125 and the cathode terminal 120, and an anode terminal 140 disposed on a second side of the workpiece 125 and the cathode terminal 120 that is opposite the first side. That is, in this view, the anode terminal 130 is disposed in the electrolytic plating solution 110 on the left side of the cathode terminal 120 and the workpiece 125, while the anode terminal 140 is disposed in the electrolytic plating solution 110 on the right side of the cathode terminal 120 and the workpiece 125.

[0039] As shown in FIG. 1, a variable power supply 135 is coupled between the cathode terminal 120 and the anode terminal 130, while a variable power supply 145 is coupled between the cathode terminal 120 and the anode terminal 140. In this example, the variable power supply 135 provides a plating current from the anode terminal 130 to the cathode terminal 120 for plating plateable surfaces on the left side of the workpiece 125, which could also be referred to as a bottom side of the workpiece 125 in some implementations. The variable power supply 145 provides a plating current from the anode terminal 140 to the cathode terminal 120 for plating plateable surfaces on the right side of the workpiece 125, which could also be referred to as a top side of the workpiece 125 in some implementations. That is, in the electroplating system 100, the cathode terminal 120 is a common cathode terminal for the anode terminal 130, the variable power supply 135, the anode terminal 140 and the variable power supply 145.

[0040] In the electroplating system 100, the anode terminal 130 includes a base portion 130a and a soluble portion 130b disposed on the base portion 130a, and the anode terminal 140 includes a base portion 140a and a soluble portion 140b disposed on the base portion 140a. In this example, the base portion 130a and the base portion 140a can be formed of a material with low electrical resistance that is not prone to consumption in the electrolytic plating solution 110, e.g., during electroplating of the workpiece 125. For instance, in some implementations the base portion 130a and the base portion 140a can each include a titanium anode basket, or an equivalent anode material.

[0041] The soluble portion 130b and the soluble portion 140b can include a solid plating metal, such as tin or other plating metal, which is soluble in the electrolytic plating solution 110. Accordingly, the soluble portion 130b and the soluble portion 140b, in this example, are consumed, at least in part, during electroplating of the workpiece 125. That is, the soluble portion 130b and the soluble portion 140b provide consumable plating metal that, in combination with plating metal already in solution in the electrolytic plating solution 110, is used to plate plateable surfaces of the workpiece 125 (and/or other workpieces). Accordingly, at least the soluble portion 130b of the anode terminal 130 and the soluble portion 140b of the anode terminal 140 would be periodically replenished, such as in implementations of the electroplating system 100 used in semiconductor device assembly manufacturing processes. In some implementations, the base portion 130a and the base portion 140a may also be periodically replaced, though less frequently than the soluble portion 130b and the soluble portion 140b.

[0042] In some implementations, the variable power supply 135 and the variable power supply 145 of the electroplating system 100 can each be a respective variable voltage power supply. In some implementations, the variable power supply 135 and the variable power supply 145 can each be a respective variable current power supply, e.g., can each include a variable current source. In this example, respective plating voltages and/or plating currents can be provided by the variable power supply 135 and the variable power supply 145. For instance, the variable power supply 135 and the variable power supply 145 can each be adjusted, or configured to provide respective plating currents based on respective areas of plateable surfaces on

each side of the workpiece 125, e.g., determined based on a ratio of the plateable surfaces area on each side of the workpiece 125.

[0043] For instance, as an example, if an area of plateable surfaces on the left (bottom) side of the workpiece 125 is nine times that of an area of plateable surfaces on the right (top) side of the workpiece 125, the variable power supply 135 and the variable power supply 145 can be adjusted such that the variable power supply 135 provides a plating current that is nine times greater than a plating current provided by the variable power supply 145, such that a current density, e.g., in A/dm², of the plating current provided by the variable power supply 135 for plating plateable surfaces on the left (bottom) side of the workpiece 125 is equal, or approximately equal, to a current density of the plating current provided by the variable power supply 145 for plating plateable surfaces on the right (top) side of the workpiece 125. That is, in the example, the variable power supply 135 can be adjusted to provide ninety percent of a total plating current in the electroplating system 100, while the variable power supply 145 can be adjusted to provide ten percent of the total plating current. It is noted that the plating current provided by the variable power supply 135 and the variable power supply 145 can also plate plateable surfaces that are disposed between the left and right sides of the workpiece 125, e.g., edges of a leadframe strip of the workpiece 125.

[0044] In some implementations, the variable power supply 135 and the variable power supply 145 can be variable voltage power supplies that are adjustable to provide respective plating voltages between zero and twenty-four volts (V). In some implementations, the variable power supply 135 and the variable power supply 145 can be variable current power supplies that are adjustable to provide respective plating currents between zero and one-hundred-fifty amperes (A). In some implementations, the variable power supply 135 and the variable power supply 145 can be configured to allow for adjustment of one of, or both of a provided voltage or a provided current.

[0045] FIG. 2 is a diagram schematically illustrating another example electroplating system 200. The electroplating system 200 includes like elements as the electroplating system 100, which are referenced with the same 100 series reference numbers in FIG. 2 as in FIG. 1. Accordingly, for purposes of brevity, those like

elements of the electroplating system 200 are not described again with reference to FIG. 2.

[0046] In the example of FIG. 2, the electroplating system 200 also includes an anode terminal 230 and an anode terminal 250 that are disposed in the electrolytic plating solution 110 on a first (left or bottom) side of the workpiece 125 and the cathode terminal 120. The electroplating system 200 further includes an anode terminal 240 and an anode terminal 260 that are disposed in the electrolytic plating solution 110 on a second (right or top) side of the workpiece 125 and the cathode terminal 120 that is opposite the first side.

[0047] As shown in FIG. 2, a variable power supply 235 is coupled between the cathode terminal 120 and the anode terminal 230, a variable power supply 245 is coupled between the cathode terminal 120 and the anode terminal 240, a variable power supply 255 is coupled between the cathode terminal 120 and the anode terminal 250, and a variable power supply 265 is coupled between the cathode terminal 120 and the anode terminal 260. In this example, the variable power supply 235 provides a plating current from the anode terminal 230 to the cathode terminal 120 for plating a first portion of plateable surfaces on the left side of the workpiece 125. Likewise, the variable power supply 255 provides a plating current from the anode terminal 250 to the cathode terminal 120 for plating a second portion of plateable surfaces on the left side of the workpiece 125. For instance, the plating current provided by the variable power supply 235 can affect plating of plateable surfaces of an upper half of the workpiece 125 on the left side the workpiece 125, while the plating current provided by the variable power supply 255 can affect plating of plateable surfaces of a lower half of the workpiece 125 on the left side the workpiece 125.

[0048] Similarly, the variable power supply 245 of the electroplating system 200 provides a plating current from the anode terminal 240 to the cathode terminal 120 for plating a first portion of plateable surfaces on the right side of the workpiece 125. Likewise, the variable power supply 265 provides a plating current from the anode terminal 260 to the cathode terminal 120 for plating a second portion of plateable surfaces on the right side of the workpiece 125. For instance, the plating current provided by the variable power supply 245 can affect plating of plateable surfaces of an upper half of the workpiece 125 on the right side the workpiece 125,

while the plating current provided by the variable power supply 265 can affect plating of plateable surfaces of a lower half of the workpiece 125 on the right side the workpiece 125. In the electroplating system 200, similar to the electroplating system 100, the cathode terminal 120 is a common cathode terminal for the anode terminal 230, the variable power supply 235, the anode terminal 240, the variable power supply 245, the anode terminal 250, the variable power supply 255, the anode terminal 260, and the variable power supply 265.

[0049] In the electroplating system 200, the anode terminal 230 includes a base portion 230a and a soluble portion 230b disposed on the base portion 230a, the anode terminal 240 includes a base portion 240a and a soluble portion 240b disposed on the base portion 240a, the anode terminal 250 includes a base portion 250a and a soluble portion 250b disposed on the base portion 250a, and the anode terminal 260 includes a base portion 260a and a soluble portion 260b disposed on the base portion 260a. In this example, as with the anodes of the electroplating system 100, the base portion 230a, the base portion 240a, the base portion 250a, and the base portion 260a can be formed of a material with low electrical resistance that is not prone to consumption in the electrolytic plating solution 110, e.g., during electroplating of the workpiece 125. For instance, in some implementations the base portions of the anode terminals of the electroplating system 200 can include respective titanium anode baskets, or equivalent anode materials.

[0050] The soluble portions 230b, 240b, 250b and 260b can include a solid plating metal, such as tin or other plating metal, which is soluble in the electrolytic plating solution 110. Accordingly, the soluble portions of the anode terminals, in this example, are consumed, at least in part, during electroplating of the workpiece 125. That is, the soluble portions of the anode terminals 230, 240, 250 and 260 provide consumable plating metal that, in combination with plating metal already in solution in the electrolytic plating solution 110, is used to plate plateable surfaces of the workpiece 125 (and/or other workpieces). Accordingly, at least the soluble portions 230b, 240b, 250b and 260b of the anode terminals 230, 240, 250 and 260 would be periodically replenished, such as in implementations of the electroplating system 200 used in semiconductor device assembly manufacturing processes. In some implementations, the base portions 230a, 240a, 250a and 260a of the anode terminals

230, 240, 250 and 260 may also be periodically replaced, though less frequently than the soluble portions.

[0051] In some implementations, the variable power supplies 235, 245, 255 and 265 of the electroplating system 200 can each be a respective variable voltage power supply. In some implementations, the variable power supplies 235, 245, 255 and 265 can each be a respective variable current power supply, e.g., can each include a variable current source. In this example, respective plating voltages and/or plating currents can be provided by the variable power supplies 235, 245, 255 and 265. For instance, the variable power supplies 235, 245, 255 and 265 can each be adjusted, or configured to provide respective plating currents based on respective areas of plateable surfaces on each side of the workpiece 125.

[0052] For instance, in this example, as in the example of FIG. 1, if an area of plateable surfaces on the left (bottom) side of the workpiece 125 is nine times larger than an area of plateable surfaces on the right (top) side of the workpiece 125, the variable power supply 235 and the variable power supply 255 can be adjusted such that they provide a combined plating current (e.g., the plating current of the variable power supply 235 plus the plating current of the variable power supply 255) that is nine times greater than a combined plating current provided by the variable power supply 245 and the variable power supply 265. That is, the variable power supplies of the electroplating system 200 can provide plating currents such that plating currents with equal, or approximately equal, current density, e.g., in A/dm², are provided for plating plateable surfaces on the left (bottom) side of the workpiece 125 and plateable surfaces on the right (top) side of the workpiece 125. For instance, in this example, the variable power supply 235 and the variable power supply 255 can each be adjusted to respectively provide forty-five percent of a total plating current in the electroplating system 200, while the variable power supply 245 and the variable power supply 265 can each be adjusted to respectively provide five percent of a total plating current in the electroplating system 200. It is noted that the plating currents provided by the variable power supplies 235, 245, 255 and 265 can also plate plateable surfaces that are disposed between the left and right sides of the workpiece 125, e.g., edges of leadframe strip of the workpiece 125.

[0053] In some implementations, the variable power supplies 235, 245, 255 and 265 can be variable voltage power supplies that are adjustable to provide

respective plating voltages between zero and twenty-four volts (V). In some implementations, the variable power supplies 235, 245, 255 and 265 can be variable current power supplies that are adjustable to provide respective plating currents between zero and one-hundred amperes (A). In some implementations, the variable power supplies 235, 245, 255 and 265 can each be configured to allow for adjustment of one of, or both of, a provided voltage or a provided current.

[0054] FIG. 3 is a diagram illustrating an example strip 300 of block molded semiconductor device assemblies viewed from a first (e.g., top) side. By way of example, the strip 300 can be the workpiece 125 of the electroplating system 100 and/or the electroplating system 200. Of course, the workpiece 125 can take other forms, such as other strips of molded semiconductor device assemblies, bare (e.g., unmolded) leadframes, one or more direct bonded metal substrates (e.g., with or without molded portions), etc.

[0055] In FIG. 3, the view of the strip 300 can correspond with the right (top) side of the workpiece 125 as illustrated in the examples of FIG. 1 and 2 discussed above. For instance, the strip 300 includes a leadframe strip 305, a block molded portion 310a, a block molded portion 310b, and a block molded portion 310c. In this example, each of the block molded portions 310a-310c can each include a plurality of individual semiconductor device assemblies, e.g., approximately nine-hundred per block molded portion in this example. These individual assemblies can be singulated (separated, etc.) into the individual semiconductor device assemblies, e.g., after plating is performed on the strip 300 using the electroplating system 100 or the electroplating system 200. Such singulation can be performed using a saw, a laser cutter, a plasma cutter, etc.

[0056] As shown in FIG. 3, the exposed portions of the leadframe strip 305 disposed around the block molded portions 310a-310c can provide mechanical support for individual leadframes of the strip 300, which are also separated from one another during a singulation process. Accordingly, in this example, the exposed portions of the leadframe strip 305 are plateable surfaces, while the block molded portions 310a-310c are not plateable surfaces. In some implementations, the leadframe strip 305 can be electrically coupled with a cathode terminal of an electroplating system, such as the cathode terminal 120 of the electroplating system 100 or the electroplating system 200, during electroplating of the strip 300.

[0057] Referring now to FIG. 4, an opposite side (e.g., bottom side) of the strip 300 from the (top) side shown in the view of FIG. 3 is illustrated, which shows the individual semiconductor assemblies, e.g., with a single semiconductor assembly indicated by a semiconductor assembly 400. Referring to FIG. 5, an example pattern of plateable surfaces of the semiconductor assembly 400 is illustrated. For instance, the example semiconductor assembly 400 shown in FIG. 5 includes a signal pad 420a, a signal pad 420b, a signal pad 420c, a signal pad 420d, a signal pad 420e, a signal pad 420f, a signal pad 420g, and a signal pad 420h, which can be portions of a leadframe (e.g., a copper leadframe) of the semiconductor assembly 400 included in the leadframe strip 305 that are exposed through a molding compound 410. As also shown in FIG. 4, the bottom side of the semiconductor assembly 400 also includes a die attach paddle 425, which can also be included in the leadframe for the semiconductor assembly 400 as part of the leadframe strip 305.

[0058] Taking FIGs. 4 and 5 together, plateable surfaces of the bottom side of the strip 300 include exposed portions of the leadframe strip 305 disposed around each of the block molded portions 310a-310c, as well as the signal pads 420a-420g and the die attach paddle 425 of each of the semiconductor assemblies 400 (e.g., approximately 1800 individual semiconductor device assemblies) of the strip 300. Accordingly, an area of the plateable surfaces of the bottom side of the strip 300 (as shown in FIG. 4) is greater than an area of the plateable surfaces of the top side of the strip 300 (as shown in FIG. 3 and described above). For instance, in an example implementation the ratio of plateable surface area of the bottom side to plateable surface area of the top side can be nine to one, or could have other ratios, e.g., twenty to one, fifteen to one, ten to one, seven to one, five to one, etc., depending on the particular implementation. Using the approaches described herein, appropriate plating voltages and/or plating currents can be used to affect electroplating of the plateable surfaces of the strip 300, and to achieve plating thickness uniformity with a desired tolerance (e.g., 10% variation or less) between the top side plateable surfaces and the bottom side plateable surfaces.

[0059] FIG. 6 is a flowchart illustrating an example method 600 for electroplating. In this example, the method 600 can be implemented by the electroplating system 200 of FIG. 2. Accordingly, for purposes of illustration, the method 600 is described with further reference to FIG. 2. In other implementations,

similar methods can be performed by electroplating systems having other configurations. For instance, the electroplating system 100 could implement a similar method with the operations of blocks 650 and 660 being omitted. In other implementations, additional operations can be added to the method 600. For instance, additional variable plating voltages and/or currents can be provided by additional variable power supplies. The particular operations of an electroplating method will depend, at least in part, on one or more of the workpiece being plated, the electroplating system used, a ratio of surface areas of plateable surfaces on each side of the workpiece, etc.

[0060] The method 600 of FIG. 6, at block 610, includes coupling the workpiece 125 with the cathode terminal 120, e.g., via the clip 120a. At block 620, the method 600 includes submerging the workpiece 125 in the electrolytic plating solution 110. The method 600 includes, at block 630, providing, from the anode terminal 230, a first plating current, e.g., from the variable power supply 235, for plating at least a first portion of plateable surfaces on the left side of the workpiece 125 (e.g., set at 50% of total plating current to account for clipped area being plated). The method 600 further includes, at block 640, providing, from the anode terminal 240, a second plating current, e.g., from the variable power supply 245, for plating at least a first portion of plateable surfaces on the right side of the workpiece 125 (e.g., set at 6% of total plating current to account for clipped area being plated). The method 600 also includes, at block 650, providing, from the anode terminal 250, a third plating current, e.g., from the variable power supply 255, for plating at least a second portion of plateable surfaces on the left side of the workpiece 125 (e.g., set at 40% of total plating current). The method still further includes, at block 660, providing, from the anode terminal 260, a fourth plating current, e.g., from the variable power supply 265, for plating at least a second portion of plateable surfaces on the right side of the workpiece 125 (e.g., set at 4% of total plating current). As described herein, the plating currents of blocks 630-660 of the method 600 can be provided by varying a voltage and/or a current of the corresponding variable power supplies.

[0061] It will be understood that, in the foregoing description, when an element, such as a layer, a region, a substrate, or component is referred to as being on, connected to, electrically connected to, coupled to, or electrically coupled to another element, it may be directly on, connected or coupled to the other element, or one or

more intervening elements may be present. In contrast, when an element is referred to as being directly on, directly connected to or directly coupled to another element or layer, there are no intervening elements or layers present. Although the terms directly on, directly connected to, or directly coupled to may not be used throughout the detailed description, elements that are shown as being directly on, directly connected or directly coupled can be referred to as such. The claims of the application, if any, may be amended to recite exemplary relationships described in the specification or shown in the figures.

[0062] As used in the specification and claims, a singular form may, unless definitely indicating a particular case in terms of the context, include a plural form. Spatially relative terms (e.g., over, above, upper, under, beneath, below, lower, and so forth) are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. In some implementations, the relative terms above and below can, respectively, include vertically above and vertically below. In some implementations, the term adjacent can include laterally adjacent to or horizontally adjacent to.

[0063] Some implementations may be implemented using various semiconductor processing and/or packaging techniques. Some implementations may be implemented using various types of semiconductor processing techniques associated with semiconductor substrates including, but not limited to, for example, Silicon (Si), Gallium Arsenide (GaAs), Gallium Nitride (GaN), Silicon Carbide (SiC) and/or so forth.

[0064] While certain features of the described implementations have been illustrated as described herein, many modifications, substitutions, changes, and equivalents will now occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the scope of the implementations. It should be understood that they have been presented by way of example only, not limitation, and various changes in form and details may be made. Any portion of the apparatus and/or methods described herein may be combined in any combination, except mutually exclusive combinations. The implementations described herein can include various combinations and/or sub-combinations of the functions, components and/or features of the different implementations described.

CLAIMS**WHAT IS CLAIMED IS:**

1. An electroplating system (100, 200), comprising:
 - a vessel (105);
 - an electrolytic plating solution (110) in the vessel;
 - a cathode terminal (120) configured to electrically connect with a workpiece (125) that is submerged in the electrolytic plating solution;
 - a first anode terminal (130, 230) in the electrolytic plating solution on a first side of the workpiece;
 - a second anode terminal (140, 240) in the electrolytic plating solution on a second side of the workpiece opposite the first side;
 - a first variable power supply (135, 235) coupled between the cathode terminal and the first anode terminal; and
 - a second variable power supply (145, 245) coupled between the cathode terminal and the second anode terminal.
2. The electroplating system of claim 1, wherein:
 - the first variable power supply includes a first variable voltage power supply;
 - and
 - the second variable power supply includes a second variable voltage power supply.
3. The electroplating system of claim 1, wherein:
 - the first variable power supply includes a first variable current power supply;
 - and
 - the second variable power supply includes a second variable current power supply.
4. The electroplating system of claim 1, wherein the first anode terminal and the second anode terminal each includes a solid plating material (130b, 230b) that is soluble in the electrolytic plating solution.

5. The electroplating system of claim 1, wherein the electrolytic plating solution includes:
methane sulfonic acid (MSA); and
a liquid plating material.
6. The electroplating system of claim 1, further comprising:
a third anode terminal (250) in the electrolytic plating solution on the first side of the workpiece;
a fourth anode terminal (260) in the electrolytic plating solution on the second side of the workpiece;
a third variable power supply (255) coupled between the cathode terminal and the third anode terminal; and
a fourth variable power supply (265) coupled between the cathode terminal and the fourth anode terminal.
7. The electroplating system of claim 6, wherein:
the third variable power supply includes a first variable voltage power supply;
and
the fourth variable power supply includes a second variable voltage power supply.
8. The electroplating system of claim 6, wherein:
the third variable power supply includes a first variable current power supply;
and
the fourth variable power supply includes a second variable current power supply.
9. The electroplating system of claim 1, wherein the workpiece is a strip (300) of block molded semiconductor device assemblies.
10. The electroplating system of claim 1, wherein
the first variable power supply is configured to provide a first plating current that is based on an area of at least one plateable surface on the first side of the workpiece; and

the second variable power supply is configured to provide a second plating current that is based on an area of at least one plateable surface on the second side of the workpiece.

11. The electroplating system of claim 1, wherein
the first variable power supply is configured to provide a first plating current for plating at least one plateable surface on the first side of the workpiece at a current density; and
the second variable power supply is configured to provide a second plating current for plating at least one plateable surface on the second side of the workpiece at the current density.

12. A method (600), comprising:
electrically coupling (610) a workpiece (125) with a common cathode terminal (120) of an electroplating system (100, 200);
submerging (620) the workpiece in an electrolytic plating solution (110);
supplying (630), from a first anode terminal (130, 230) submerged in the electrolytic plating solution, a first plating current for electroplating at least one plateable surface on a first side of the workpiece; and
supplying (640), from a second anode terminal (140, 240) submerged in the electrolytic plating solution, a second plating current for electroplating at least one plateable surface on a second side of the workpiece, the second plating current being different than the first plating current, the second side of the workpiece being opposite the first side of the workpiece.

13. The method of claim 12, wherein the workpiece is a strip of block molded semiconductor device assemblies (300).

14. The method of claim 12, wherein:
the first plating current is based on an area of the at least one plateable surface on the first side of the workpiece; and
the second plating current is based on an area of the at least one plateable surface on the second side of the workpiece.

15. The method of claim 12, wherein the first plating current is used for plating a first portion of the at least one plateable surface on the first side of the workpiece, and the second plating current is used for plating a first portion of the at least one plateable surface on the second side of the workpiece,

the method further comprising:

supplying (650), from a third anode terminal (250) submerged in the electrolytic plating solution, a third plating current for electroplating a second portion of the at least one plateable surface on the first side of the workpiece; and

supplying (660), from a fourth anode terminal (260) submerged in the electrolytic plating solution, a fourth plating current for electroplating a second portion of the at least one plateable surface on the second side of the workpiece.

16. The method of claim 15, wherein:

the third plating current is different than the first plating current; and
the fourth plating current is different than the second plating current.

17. The method of claim 15, wherein:

the third plating current is equal to the first plating current; and
the fourth plating current is equal to the second plating current.

18. The method of claim 15, wherein:

the third plating current is equal to the first plating current; and
the fourth plating current is different than the second plating current.

19. An electroplating system (200), comprising:

a vessel (105);

an electrolytic plating solution (110) in the vessel including a liquid plating material;

a common cathode terminal (120) configured to electrically connect with a workpiece (125) that is submerged in the electrolytic plating solution;

a first anode terminal (230) in the electrolytic plating solution on a first side of the workpiece;

a second anode terminal (240) in the electrolytic plating solution on the first side of the workpiece;

a third anode terminal (250) in the electrolytic plating solution on a second side of the workpiece opposite the first side;

a fourth anode terminal (260) in the electrolytic plating solution on the second side of the workpiece;

a first variable power supply (235) coupled between the common cathode terminal and the first anode terminal;

a second variable power supply (245) coupled between the common cathode terminal and the second anode terminal;

a third variable power supply (255) coupled between the common cathode terminal and the third anode terminal; and

a fourth variable power supply (265) coupled between the common cathode terminal and the fourth anode terminal.

20. The electroplating system of claim 19, wherein:

the first variable power supply includes a first variable voltage power supply;

the second variable power supply includes a second variable voltage power supply;

the third variable power supply includes a third variable voltage power supply;

and

the fourth variable power supply includes a fourth variable voltage power supply.

21. The electroplating system of claim 19, wherein:

the first variable power supply includes a first variable current power supply;

the second variable power supply includes a second variable current power supply;

the third variable power supply includes a third variable current power supply;

and

the fourth variable power supply includes a fourth variable current power supply.

22. The electroplating system of claim 19, wherein the workpiece is a strip of block molded semiconductor device assemblies (300).