$$Sn \rightarrow Sn^{2+} + 2e^{-} \quad (2)$$

When low alpha tin is used as the tin anode, the anode material contains only small amounts of alpha emitting impurities and the resulting electrochemical dissolution of low alpha tin metal forms low alpha tin electrolyte that has low concentration of alpha particle emitters, as desired.

The anolyte chamber has an inlet for receiving one or more fluids, an outlet for removing the anolyte and at least one sensor configured for measuring concentration of metal ions in the anolyte. Examples of fluids that can be introduced through the inlet into the anolyte chamber include water, a concentrated aqueous solution of an acid, a more dilute aqueous solution of an acid, an electrolyte containing acid and a metal salt, and combinations thereof. The apparatus typically includes one or more pumps configured for delivering one or more of these fluids into the anolyte chamber. The outlet in the anolyte chamber serves for removal of portions of anolyte (where the portions may have variable sizes) from the anolyte chamber. A pump is typically used to remove the anolyte from the anolyte chamber. For example, a portion of the anolyte can be pumped out of the anolyte chamber through the anolyte chamber outlet, when the concentration of metal ions in the anolyte reaches a target concentration range. In some embodiments the anolyte chamber is further equipped with a cleaning and draining system, which allows the anolyte to be recirculated and filtered during recirculation. The same system may be adapted to remove a portion of the anolyte to a drain, when needed. In one example of anolyte recirculation, a portion of the anolyte is removed from the anolyte chamber through the outlet in the anolyte chamber, passed through a filter to remove particles, and is returned to the anolyte chamber after filtration.

In some embodiments, the anolyte chamber may include more than one sensor. For example, a set of sensors configured for measuring the concentration of acid and metal ions in the anolyte can be included. An example of such set of sensors is a combination of a densitometer and a conductivity meter. The sensors configured for measuring the concentrations of metal ions and acid concentration generally can measure any set of properties of the anolyte that can be correlated with metal ion and acid concentrations. For example, when tin electrolyte is generated, the sensor for measuring tin ion concentration can be a densitometer that measures the density of

cathodes coated with platinum or with iridium oxide, where the coating catalyzes the cathodic reaction. Such coatings are provided, for example, by Optimum Anode Technologies of Camarillo, CA. A cathodic reaction is shown in equation (3).

$$2H^+ + 2e^- \rightarrow H_2 \qquad (3)$$

The separation membrane allows the anions to pass through the membrane, but preferably prevents metal ions from passing. The purpose of the membrane is to keep the catholyte substantially free from the ions of the metal, which, if present, would be reduced at the cathode and will lead to its degradation. The membrane allows anions, such as methanesulfonate, and sulfate to pass through the membrane, when current is applied to the electrodes. In some implementations, water and acid (e.g., MSA) may also pass through the membrane, when current is applied. Examples of suitable anionic membranes include polymers functionalized with quaternary ammonium moieties, provided on a support structure. One example of such polymeric functionalized anionic membrane is Fumasep® FAB-PK-130 PEEK (polyether ether ketone) reinforced anion exchange membrane available from Fumatech of Bietigheim-Bissingen, Germany.

One embodiment of an electrolyte generating apparatus is illustrated by Figure 2, which shows a cross-sectional schematic view of an apparatus where the anode-holding chamber 201 and a cathode-holding chamber 203 are directly separated by an anion-permeable membrane 205. The low alpha tin anode 207 resides in anolyte 209, which initially (before current is applied to the electrodes) is composed of an aqueous solution of acid (e.g., methansulfonic acid and/or sulfuric acid), and, in some embodiments, may include Sn^{2+} ions in addition to the acid. As the anode 207 is dissolved during the electrolyte generating process, the concentration of Sn^{2+} ions in the anolyte is increased. The concentration of the tin ions is measured during the generation process by a densitometer 211, which is in communication with the controller 213. Alternatively, the concentration of the tin ions is measured by a combination of a densitometer and a conductivity meter. The anolyte chamber 201 has an inlet 215 for receiving an aqueous solution of acid (e.g., methanesulfonic acid or sulfuric acid) from the source of acid 217, and deionized water from the source of deionized water 219. In those embodiments, where the anolyte initially contains a solution of Sn^{2+} ions, a pre-made, or commercially available solution containing tin

The cathode-housing assembly is equipped with a first anion-permeable membrane 329 that, in the depicted embodiment, directly separates the anolyte chamber and the first catholyte chamber. The membrane can be mounted onto a wall having one or more openings that are covered by the membrane after the membrane is mounted. The first catholyte chamber ~~321~~ 323 and the second catholyte chamber 325 are separated by a second anion-permeable membrane 331, which may also be mounted onto a wall with openings. The first catholyte chamber has an outlet 333, and a fluidic conduit 335, which is configured to deliver the catholyte from the first catholyte chamber ~~321~~ 323 to the anolyte chamber through an anolyte chamber inlet 337. For example, the anolyte may be dosed with the first catholyte from the first catholyte chamber, if the concentration of acid in the anolyte becomes too low, because, in the depicted embodiment the first catholyte is more acidic than the anolyte, and can be used as the source of acid. The anolyte may be also dosed with the first catholyte from the first catholyte chamber when tin ions that inadvertently migrate from the anolyte through the first membrane need to be flushed from the first catholyte chamber. When the first catholyte is transferred from the first catholyte chamber to the anolyte chamber, the level of the first catholyte would drop and the first catholyte would need to be replenished. In the depicted embodiment the first catholyte is replenished via a fluidic conduit 339, which connects the second catholyte chamber with the first catholyte chamber. In some embodiments, the fluidic conduit 339 is a hollow tube that is open from both ends, and which permits the second catholyte to automatically transfer to the first catholyte chamber, until the pressure in both chambers is equalized. In some embodiments the fluidic conduit 339 is a long and narrow line, which impedes diffusion of the first catholyte into the second catholyte chamber, and thereby impedes inadvertent transfer of tin ions into the second catholyte chamber.

The second catholyte chamber has an inlet and a fluidic conduit 341 coupled with this inlet, where the fluidic conduit is connected with a source of acid 343, and a source of water 345. Acid and water can be added through the conduit 341 to the second catholyte in the second catholyte chamber, as desired. The source of water 345, in the depicted embodiment, is also fluidically connected via a conduit 347 to the anolyte chamber, and the apparatus allows for water dosing into the anolyte. The tin anode 303 and the cathode 327 are electrically connected to a power supply 349,

which is configured to bias the anode positively at a potential that is sufficient to cause dissolution of the anode.

The fluidic configuration shown in Figure 3A is referred to as a cascade configuration. In this configuration the second catholyte cascades from the second catholyte chamber through conduit to the first catholyte chamber, and the first catholyte, in turn, cascades from the first catholyte chamber through conduit to the anolyte in the ~~first~~ anolyte chamber. The second catholyte chamber is fed with acid and water through the sources of acid and water.

In one modification of the cascade configuration, the apparatus further comprises a fluidic conduit connecting the source of acid 343 with the anolyte chamber 301. Thus, in this configuration, the anolyte can receive acidic solution both from the first catholyte chamber and from the source of acid. In some embodiments the source of acid is a removable tote that is fluidically connected to the anolyte chamber and a second catholyte chamber through a buffer tank, that is configured to provide an uninterrupted supply of acid.

In an alternative fluidic configuration, depicted in Figure 3B, the apparatus comprises a fluidic conduit connecting the source of acid 343 with the anolyte chamber 301, but does not have the conduit 335 connecting the first catholyte chamber with the anolyte chamber. Instead the apparatus includes a fluidic conduit 336 connected with the first catholyte chamber at the outlet 333 and configured to deliver a portion or all of the first catholyte to drain, or for recycling it outside the electrolyte generating apparatus. In this configuration, the anolyte is replenished with acid only from the source of acid 343.

In the configurations shown in Figures 3A and 3B, the first catholyte chamber 323 does not have a dedicated inlet for introduction of acidic solution, and, instead, receives all necessary acid from the second catholyte chamber 325 through the conduit 339. In an alternative fluidic arrangement (which is applicable to both configurations shown in Figure 3A and 3B), the conduit ~~321~~ 339 is absent, and instead the first catholyte chamber ~~325~~ 323 contains an inlet in fluidic communication with an acid source 343, and the apparatus is configured to dose the first catholyte in chamber ~~325~~ 323 with an acid from this source. Optionally, the source of water 345 may be also

filtration of various fluidic streams in the system. For example, the anolyte directed from the anolyte chamber to the electrolyte storage tank, in some embodiments, is passed through a filter before it enters the electrolyte storage tank to remove any insoluble impurities.

In some embodiments the apparatus presented herein, is further configured to deoxygenate the electrolyte. Deoxygenation is preferably performed in the anolyte chamber, and is primarily used to prevent oxidation of Sn^{2+} ions to Sn^{4+} ions. Formation of Sn^{4+} ions is highly undesirable, because it can lead to precipitation in the electrolyte and generally to deterioration of quality of the formed electrolyte. In some embodiments deoxygenation is performed by bubbling an inert gas (e.g., nitrogen or argon) through the anolyte, e.g., in the anolyte chamber. Thus, in some embodiments, the apparatus includes a conduit connected to a source of an inert gas that is configured to bubble the inert gas through the anolyte in the anolyte chamber. Further, in some embodiments, similar deoxygenation is also performed in the electrolyte storage tank, and, in some cases, in the catholyte chamber (e.g., first and/or second catholyte chamber).

The fluidic features of the electrolyte generating apparatus, in some embodiments, communicate with a system controller, where the controller is also configured to communicate with one or more sensors of the electrolyte-generating apparatus. The sensors provide feedback to the controller, which is programmed with the instructions to adjust one or more process parameters in response to the data provided by the sensors. Figure 4 provides a cross-sectional schematic view of an electrolyte-generating apparatus, illustrating different types of sensors that can be used to provide data to the controller for accomplishing fully or partially automated generation of the electrolyte. The apparatus shown in Figure 4 is similar to the apparatus of Figure 3A, and it is understood that the fluidic features shown in Figure 3A and Figure 3B are to be used with one or more sensors shown in Figure 4. The apparatus shown in Figure 4 differs from the apparatus shown in Figure 3A, in that the low alpha tin anode in Figure 3A is a single piece of low alpha tin metal (available from Mitsubishi Materials Corporation of Tokyo, Japan or Honeywell International, Inc. of Morristown, NJ), whereas the apparatus shown in Figure 4 employs a plurality of low alpha tin pellets placed in an ion-permeable container, where the pellets serve

feedstock tote. By setting the positions of the pneumatic valves to an appropriate combination of states, the concentrated acid solution can be transferred from the acid tote 603 to the cathode-housing assembly chamber 611, or to the anolyte chamber 613. The part of the total anolyte recirculation flow that returns to the anolyte chamber 613 without passing through the anode reaction zone 606 is monitored by a flow meter 637 before or after being filtered by filter ~~117~~.

The same dosing and transfer pump 631 is configured to draw a known amount of fluid out of the cathode-housing assembly 611 and to move it to either a waste drain, or to the anolyte chamber 613. In an embodiment previously illustrated with reference to Figure 3A, pump 631 draws catholyte from the first catholyte chamber (mid chamber) of the cathode-housing assembly, and transfers the acidic catholyte to acidify the anolyte product in the anolyte chamber 613.

This process serves three primary functions. First, because the anion-permeable membranes 617 and 621 are not always completely effective in inhibiting positive ions (metal and hydrogen ions) from migrating across the membranes under the influence of the electric field applied to the electrolytic cell, a small amount of migrated metal ions and protons can transfer through the first anion-permeable membrane 617 (closest to the anode) and can start to accumulate in the first catholyte chamber (middle chamber) 615. In order to avoid the accumulation of metal ions in the first catholyte chamber 615 to a high enough concentration that would eventually allow them to move across the second membrane 621 to the second catholyte chamber 619 and be reduced to metal at the cathode in the second catholyte chamber 619, the catholyte is periodically drawn from the first catholyte chamber 615 and is either sent to waste, or, in some embodiments, is transferred to the anolyte chamber 613. The first catholyte chamber 615 preferably contains a relatively small volume of catholyte relative to that in the cathode-housing chamber. In some embodiments the total volume of catholyte (including catholyte in the first and second chambers) is about 30 L, of which the volume of the catholyte in the first chamber is only 1.5 L. In some embodiments the volume of catholyte in the first catholyte chamber is less than about 20%, such as less than about 10% of the total volume of catholyte (catholyte in first and second chambers combined). In some embodiments the volume of the first catholyte chamber in the apparatus is less than about 20%, such as less than about

The apparatus depicted in Figures 6A-6E is further configured for supplying deionized water to both the anolyte chamber 613 and the second catholyte chamber 619. An anti-diffusion valve 645 is used in combination with other valves to direct DI water to catholyte or anolyte chambers. The anti-diffusion valve 645 is designed to prevent water stagnation and back-contamination of the DI water feed source. The anolyte chamber 613 has a drain 647 at its base through which the anolyte is drawn out by the main circulation pump 649. The drawn anolyte can be directed via line 651 to any of a number of destinations. When the anolyte reaches the required concentrations specified for generated electrolyte, the anolyte product from the anolyte chamber outlet can be transferred to the electrolyte storage container tote 601. If the required concentration of metal ions in the anolyte is not reached, or if transfer of product is not desired for any reason, the anolyte from the outlet can be transferred to the cooling portion of anolyte chamber 629, where the heat exchanger is located, or it can be injected back into the anode porous bed region 606 of the anolyte. The direction of the anolyte flow from the outlet can be controlled by periodically adjusting the settings of the valves. For example, periodically the recirculating anolyte is directed to the electrolyte storage tote, if the anolyte has target concentrations of components.

A flow meter 653 measures the fraction of the total flow of the anolyte that is used for recirculation. That flow starts from the outlet 647 and passes through the pump 649. The amount and/or fraction of flow going to either the anode reaction zone 606 via a manifold ~~655~~ at the bottom of the reaction zone, or to the cooling portion 629 of the anolyte chamber is regulated by a control valve 657. In the illustrated example this regulation is accomplished by opening of a needle valve knob 659 of the anode reaction flow branch.

A diaphragm pump 661 is used for removing materials from the electrolyte generator for maintenance and cleaning. Depending on the state of two way valve 663, the pump 661 can remove catholyte via line 665 from the second catholyte chamber, or it can remove anolyte from the anolyte outlet line before that line reaches the main circulation pump 649.

As it was previously mentioned, the metal pellets are supplied to the anode reaction zone 606 via a metal pellet hopper 605. The hopper has a lid 667, and one or more surfaces slanted from top to bottom, such that the pellets supplied from the top opening are contained and the flow of pellets is directed through the reaction chamber pellet entrance (or throat) ~~669~~ and into the anode reaction zone 606. When the electrolyte generator is "on" and an anodic current and potential is applied to the anode buss 671, current passes onto the anode charge plate 607 and to the pellets. Two anode busses 671 run along the periphery of the anode reaction zone 606 and pass through the plastic wall of the anode hopper 605 using a connection bolt.

The apparatus illustrated in Figures 6A-6F is configured for maintaining the level of hydrogen below the lower explosion limit (LEL). The apparatus includes a main access lid 673 which covers the top of the electrolyte generation reactor and is functional in controlling the flow of air, such that the hydrogen gas level in the chamber below the lid remains lower than the LEL for hydrogen in air. Dilution air (which acts as a diluent gas in this case) enters the chamber between the top lid 673 and an inner lid 675 covering the cathode-containing assembly 611 through a set of inlet openings 677, which are visible in the view of the apparatus shown in Figure 6E The diluent gas moves substantially parallel to the horizontal plane in the space between the lids 673 and 675, mixing with hydrogen-containing gas that exits the cathode-housing assembly 611 through openings 678 in the inner lid 675. The mixed gas then reaches the exhaust manifold distribution plate 679, enters the exhaust manifold 681 and exits through the exhaust 683.

In the depicted embodiment, an additional flow of a diluent gas is directed into the space above the catholyte above the cathode 623 and below the inner lid 675. The structure of the inner lid and of the cathode-housing assembly is visible in Figures 6F-6I. The second catholyte chamber 619 contains a hydrogen-generating cathode 623 which is also referred to as a dimensionally stable cathode (DSC), which generates hydrogen gas during electrolyte generation. The cathode has external connection buss points 685, which are connected to a power supply that negatively biases the cathode during electrolyte generation. Inert DSC cathodes are commonly used as a hydrogen generating electrodes in electro-synthesis and fuel cell applications as a well as cathodes for the chloro-alkali industry. These cathodes are distinct from

process can be used if using different measured intrinsic property measurements pairs. The minimum number of measurements is equal to the number of materials (ionic pairs) being measured (two for a two component system with a single anion, or three for three components with three components and a single anion). Examples of intrinsic properties that could be used/measured in combination include density, viscosity, osmotic pressure, conductivity, refractive index, pH, and optical absorbance at a given frequency. As some of these intrinsic variables can have strong temperature dependency (density and optical absorbance of a fluid being notable exceptions) it is also important to measure the temperature and record change in property response with temperature if temperature is not fixed during the measurement, and to know the differential change in the response with temperature. Many sensors include build in thermal couples or thermistors.

The passage of current through the resistive electrolyte in the reactor generates heat. In some embodiments, a heat exchanger is provided in either the anolyte chamber, the catholyte chamber, or both. In the depicted example, the heat exchanger is provided only in the cooling section 629 of the anolyte chamber 613. The illustrated heat exchanger is composed of a main titanium pipe inlet manifold 703, which feeds several (e.g., 4) weld-connected heat exchange titanium pipes 704 of smaller diameter that serpentine back and forth in the anolyte reactor cooling area. At the opposite end of the chamber, the smaller tubes 704 connect to an exit port manifold 705. A cooling fluid, such as facility liquid cooling water or a cooling fluid generated and circulated by an external chiller unit, circulates through the heat exchanger to cool the anolyte and maintain it at a target temperature (e.g., at less than about 40 °C). In one embodiment, the temperature of the anolyte is controlled by opening a liquid cooling water inlet valve when the temperature of the electrolyte exceeds a target maximum temperature. In other cases the temperature is actively controlled using the sensed temperature and a feedback controller of an external fluidic chiller unit. An anolyte temperature sensor is provided for this purpose.

The depicted electrolyte-generating reactor further contains an overflow weir ~~707~~. A fluid entering the anode reaction region and passing upwards through the porous anode particles flows upwards to an overflow porous region or "weir" 707. After the flow reaches the weir, it changes direction and then flows through the anode

current is applied) contains tin (II) salt in addition to the acid. For example, in one embodiment the anolyte initially contains tin (II) methanesulfonate and MSA, while catholyte contains only MSA at a higher concentration than the concentration of MSA in the anolyte. It was discovered that it is preferable (although not necessary) to start the process by providing tin ions in the anolyte that would be at least about 60 %, more preferably at least about 80 % of the tin target concentration, and particularly preferable at least about 90% of the tin target concentration, and to start with an acid concentration in the anolyte of less than 1 M, such as between about 0.3 – 0.7 M, e.g., 0.5 – 0.7 M. For example, in some embodiments it is preferable to provide a concentration of tin ions in the anolyte (before application of current) of at least about 200 g/L, such as at least about 250 g/L. Providing tin ions in the anolyte before application of current provides the advantage of improved anolyte and system stability. Specifically, it was discovered that solutions containing low concentrations of tin ions (and secondly high concentrations ~~or~~ of acid) are relatively less stable than solutions with higher tin ion concentrations (and low acid). By providing a relatively high concentration of tin ions before current is applied, it is ensured that the concentration of tin ions will only increase after the current is applied and the anolyte will remain highly stable. The formation of undesirable Sn^{4+} ions and associated particle generation is generally suppressed under these preferred operating anolyte concentrations. Furthermore, if no tin ions are in the anolyte before application of current, the concentration of tin ions will increase from zero to a target concentration (e.g., to 300 g/L), which may cause undesired osmotic effects and can impact the membrane more than a more modest increase in tin ion concentration (e.g., from 250 g/L to 300 g/L). The maintenance of a relatively low concentration of acid (e.g., 0.3 - 1M concentration) in the anolyte also confers higher stability to the anolyte.

Referring again to Figure 8A, in operation 801, current is supplied to the reactor to cause dissolution of metallic (e.g., low alpha tin) anode. The current is supplied such that the total charge delivered to the system is sufficient to generate the target concentration range of tin ions in the anolyte. For example if the broad target concentration range for tin ions is between about 280 – 320 g/L, the current is supplied for an amount of time that is necessary to generate the required amount of tin ions in the anolyte and to reach the target concentration in a known volume of the anolyte. The time is calculated based on Faraday's law of electrolysis, given that the level of supplied current and the volume of the anolyte are known parameters. The

4. The apparatus of claim 3, wherein the first catholyte chamber and the second catholyte chamber are fluidically connected through a fluidic conduit, wherein the fluidic conduit allows for transfer of the second catholyte from the second catholyte chamber to the first catholyte chamber.

5. The apparatus of claim 1, wherein the apparatus comprises a single piece metal anode.

6. The apparatus of claim 1, wherein the anolyte chamber comprises an ion - permeable container for containing a plurality of metal pieces that serve as an anode.

7. The apparatus of claim 6, wherein the anolyte chamber further comprises a receiving port for receiving a plurality of metal pieces into the ion-permeable container.

8. The apparatus of claim 7, wherein the receiving port comprises a gravity fed hopper.

9. The apparatus of claim 7, wherein the receiving port comprises a sensor configured to communicate to a system controller when the level of metal pieces in the receiving port is low.

10. The apparatus of claim 1, wherein the apparatus comprises a hydrogen-generating cathode positioned in the second catholyte chamber.

11. The apparatus of claim 10, wherein the apparatus comprises a diluent gas conduit configured to deliver a diluent gas to a space above the second catholyte, and to dilute hydrogen gas accumulating in that space, wherein the space above the second catholyte is covered with a first lid having one or more openings that allow for transfer of diluted hydrogen gas into a space above the first lid.

12. The apparatus of claim 11, further comprising: a second lid over the first lid and spaced apart from the first lid such that there is a space between the first and the second lids; and a second diluent gas conduit configured to deliver a diluent gas to a space between the first and second lids and to move the diluted hydrogen gas from the space between the first and second lids towards an exhaust.

13. The apparatus of claim 1, wherein the anolyte chamber comprises a cooling system.

14. The apparatus of claim 1, wherein the anolyte chamber comprises a cooling system that is located in a cooling portion of the anolyte chamber away from the active anode.

15. The apparatus of claim 14, further comprising a fluidic conduit and an associated pump configured to deliver the anolyte from the anolyte chamber outlet located proximate the active anode to the cooling portion of the anolyte chamber.

16. The apparatus of claim 1, wherein the apparatus is configured to measure the concentration of metal ions in the anolyte with the one or more sensors, and to communicate the measurement to an apparatus controller.

17. The apparatus of claim 16, wherein a single sensor is used for measuring the concentration of metal ions in the anolyte and the sensor is a densitometer.

18. The apparatus of claim 16, wherein at least two sensors are used for measuring the concentration of metal ions in the anolyte, wherein the at least two sensors comprise a densitometer and a conductivity meter.

19. The apparatus of claim 18, wherein the densitometer and the conductivity meter are further configured for measuring the concentration of acid in the anolyte.

20. The apparatus of claim 19, wherein the conductivity meter is an inductive probe.

21. The apparatus of claim 1, further comprising a sensor configured to measure a concentration of acid in the second catholyte.

22. The apparatus of claim 1, wherein the apparatus comprises a controller having program instructions for automatically generating electrolyte having a concentration of metal ions in a target range.

23. The apparatus of claim 1, further comprising a fluidic connection allowing for automated transfer of the anolyte from the anolyte chamber to an electrolyte storage tank, wherein the electrolyte storage tank is fluidically connected to an electroplating

tool, and wherein the apparatus is configured to deliver the electrolyte from the electrolyte storage tank to the electroplating tool.

24. The apparatus of claim 1, further comprising an accessible compartment configured for holding a replaceable source of an acid, wherein the replaceable source of an acid is fluidically connected with the inlet of the anolyte chamber, and said fluidic connection comprises an acid buffer tank, wherein the apparatus is configured to deliver the acid from the replaceable source of the acid to the acid buffer tank and from the acid buffer tank to the anolyte chamber.

25. An apparatus for automatically generating an electrolyte containing metal ions, the apparatus comprising:

(a) an anolyte chamber configured to contain an active anode and an anolyte, wherein the apparatus is configured to electrochemically dissolve the active anode into the anolyte, and to thereby form the electrolyte containing metal ions, wherein the anolyte chamber comprises:

(i) an inlet for receiving a fluid;

(ii) an outlet for removing the anolyte; and

(iii) one or more sensors configured for measuring a concentration of metal ions in the anolyte;

(b) a catholyte chamber configured to contain a cathode and a catholyte, wherein the catholyte chamber is separated from the anolyte chamber by an anion permeable membrane; and

(c) a controller having program instructions for automatically generating an electrolyte having a concentration of metal ions in the anolyte chamber in a target range using data provided by the one or more sensors.

26. A system comprising:

(a) an electroplating apparatus that utilizes an electrolyte containing metal ions;

(b) an electrolyte-generating apparatus configured for automatic generation of the electrolyte, wherein the electrolyte-generating apparatus is in communication with the electroplating apparatus; and

(c) one or more system controllers comprising program instructions for communicating demand for electrolyte from the electroplating apparatus to the electrolyte-generating apparatus and for generating electrolyte having concentration of metal ions in a target range.

27. A method of generating an electrolyte containing metal ions, the method comprising:

(a) passing current through an electrolyte-generating apparatus, wherein the electrolyte-generating apparatus comprises:

(i) an anolyte chamber cotaining an active metal anode and an anolyte; and

(ii) a catholyte chamber containing a cathode and a catholyte, wherein the catholyte chamber is separated from the anolyte chamber by an anion-permeable membrane,

wherein the active metal anode is electrochemically dissolved into the anolyte as current is passed;

(b) measuring concentration of metal ions in the anolyte, and automatically communicating the concentration to an apparatus controller, wherein the apparatus controller comprises program instructions for processing the data on concentration of metal ions and for automatically instructing the electrolyte-generating apparatus to act based on these data; and

(c) automatically transferring a portion of the anolyte from the anolyte chamber to an electrolyte storage container, when concentration of metal ions in the anolyte falls within a target range.

28. The method of claim 27, wherein the concentration of metal ions is measured while the current is passed through the electrolyte-generating apparatus.

29. The method of claim 27, wherein the active metal anode comprises low alpha tin metal and the anolyte comprises Sn^{2+} ions.

30. The method of claim 27, wherein the anolyte further comprises acid, and wherein the method further comprises measuring concentration of acid in the anolyte; automatically communicating concentration of acid to the apparatus controller, wherein the apparatus controller comprises program instructions for processing the data on acid concentration and for instructing the electrolyte-generating apparatus to act based on these data.

31. The method of claim 30, further comprising automatically adding acid to the anolyte if the concentration of acid is less than a target concentration range.

32. The method of claim 27, wherein the method further comprises dosing the anolyte with an acidic solution, after a portion of the anolyte has been transferred to the electrolyte storage container, and repeating operations (a)-(c).

33. The method of claim 32, wherein no more than 10% of the total volume of anolyte is transferred from the anolyte chamber per one (a)-(c) cycle.

34. The method of claim 33, comprising performing at least three (a)-(c) cycles with addition of acid to anolyte after each cycle.

35. The method of claim 33, comprising performing at least three (a)-(c) cycles with addition of acid to anolyte and catholyte after each cycle.

36. The method of claim 27, wherein the anolyte and catholyte comprise an acid selected from the group consisting of methansulfonic acid (MSA), sulfuric acid, and mixtures thereof.

37. The method of claim 27, further comprising flowing a diluent gas to the catholyte chamber to dilute a hydrogen gas generated by the cathode.