US 20090090634A1

(19) **United States**

(12) **Patent Application Publication**

Radatz et al.

(10) **Pub. No.: US 2009/0090634 A1**

(43) **Pub. Date: Apr. 9, 2009**

(54) **METHOD OF PLATING METAL ONTO TITANIUM**

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(21) Appl. No.: **12/284,813**

(22) Filed: **Sep. 25, 2008**

Related U.S. Application Data

(60) Provisional application No. 60/997,553, filed on Oct. 3, 2007.

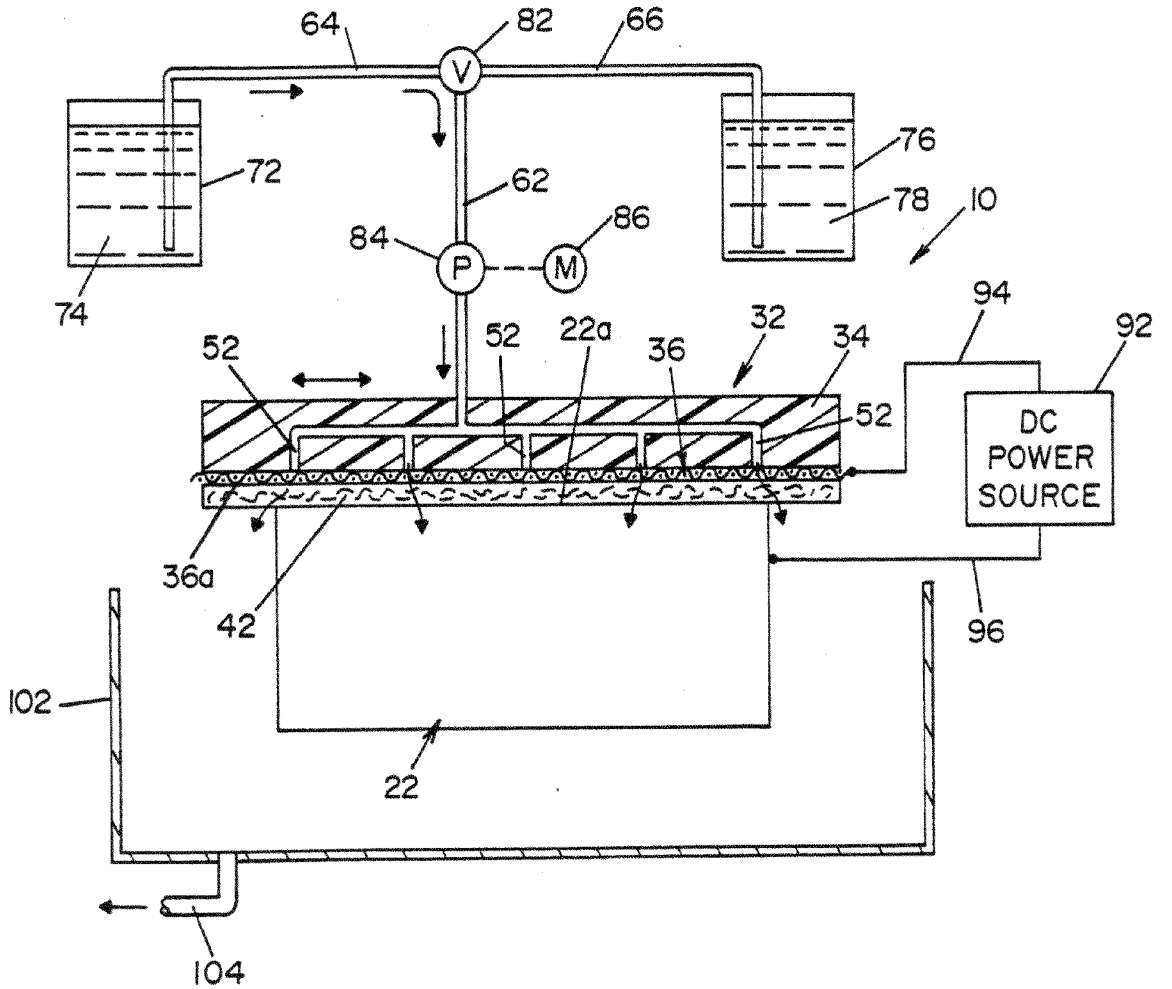
Publication Classification

(51) **Int. Cl.**
C25D 5/34 (2006.01)
C25D 17/14 (2006.01)

(52) **U.S. Cl.** **205/206**; 204/275.1; 204/242

(57) **ABSTRACT**

A method of plating a metal onto a titanium surface comprising a surface cleaning step, an anodic etching step, a cathodic activation step and a plating step.



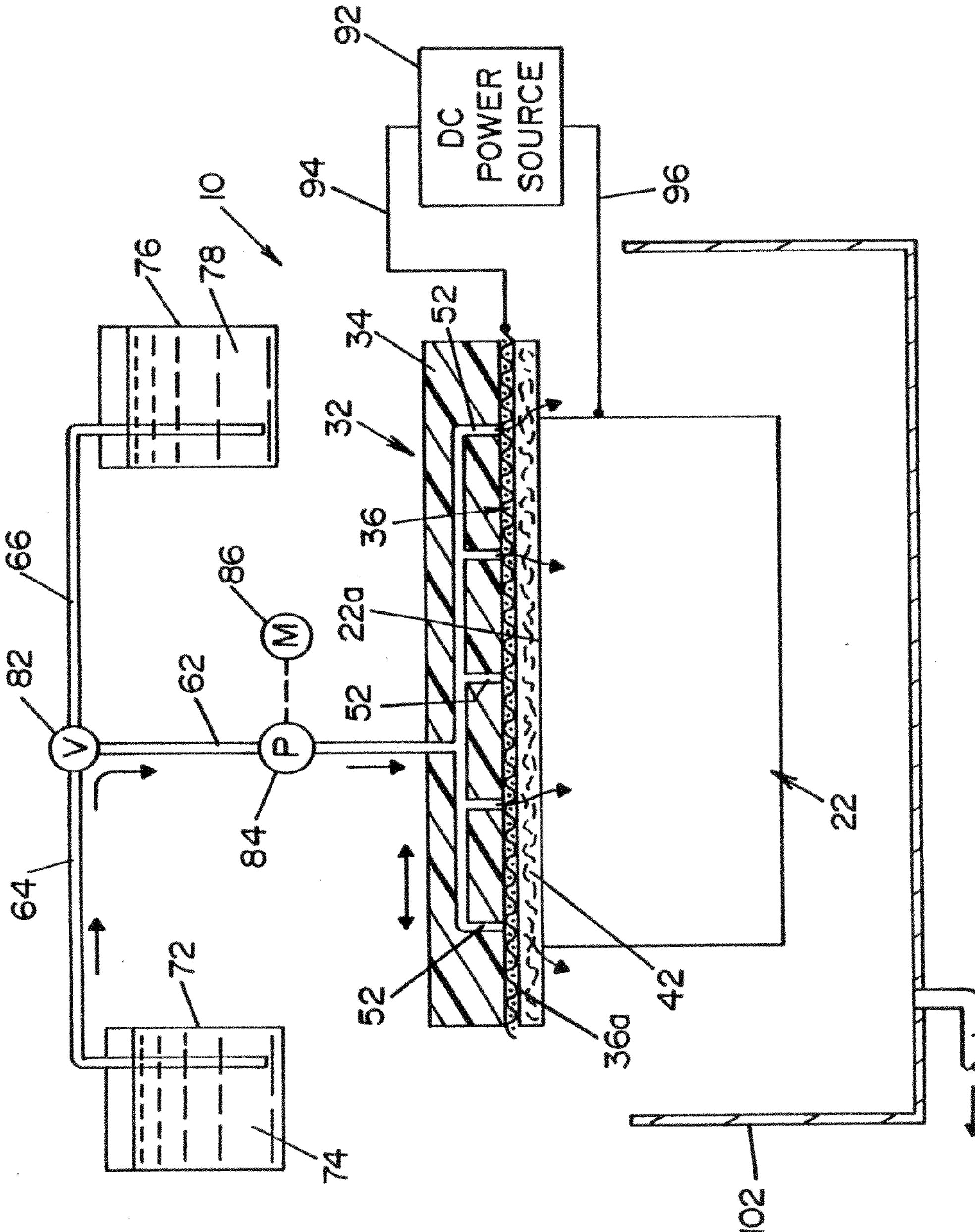

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FIG. 1

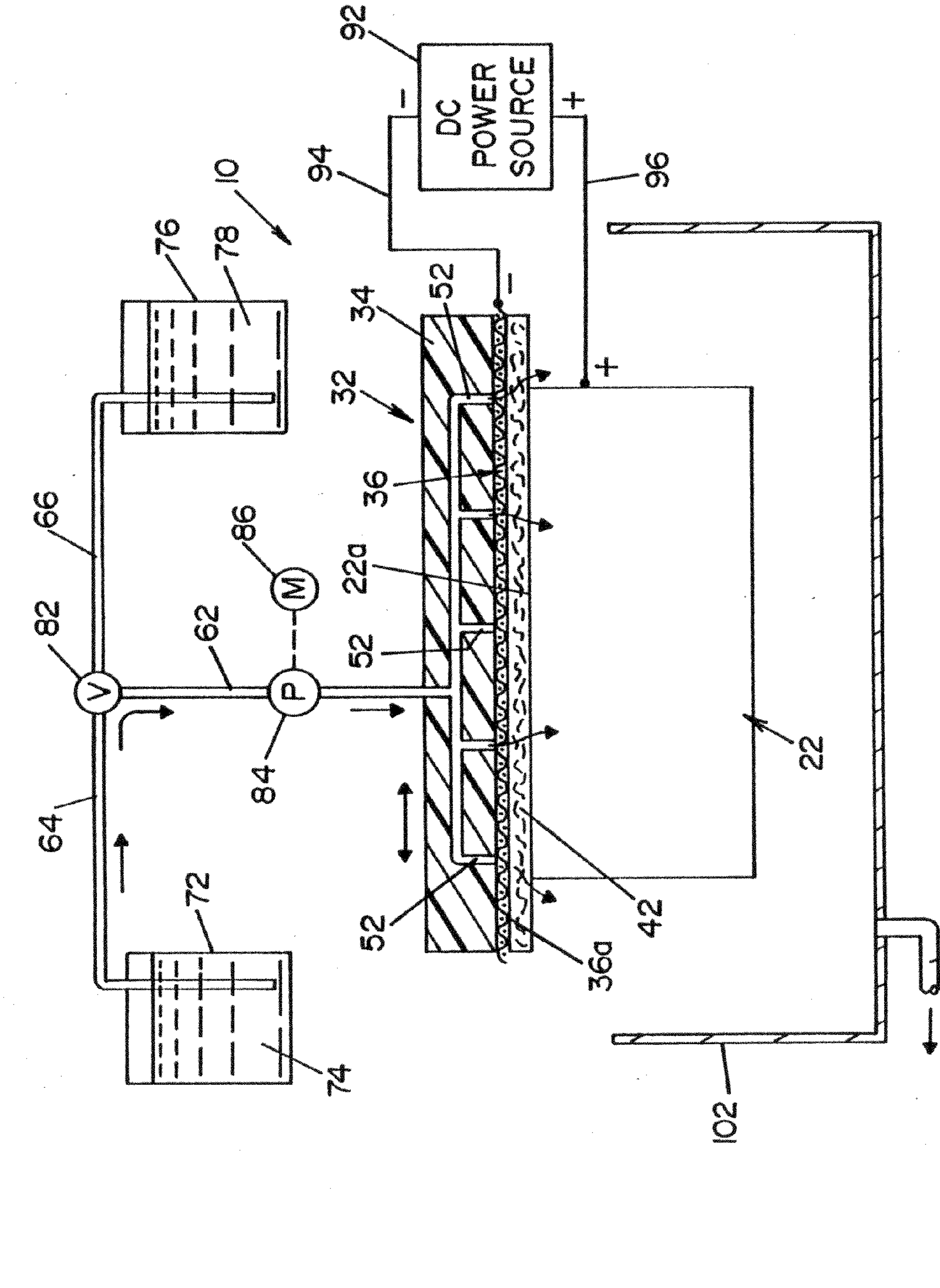
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FIG. 2

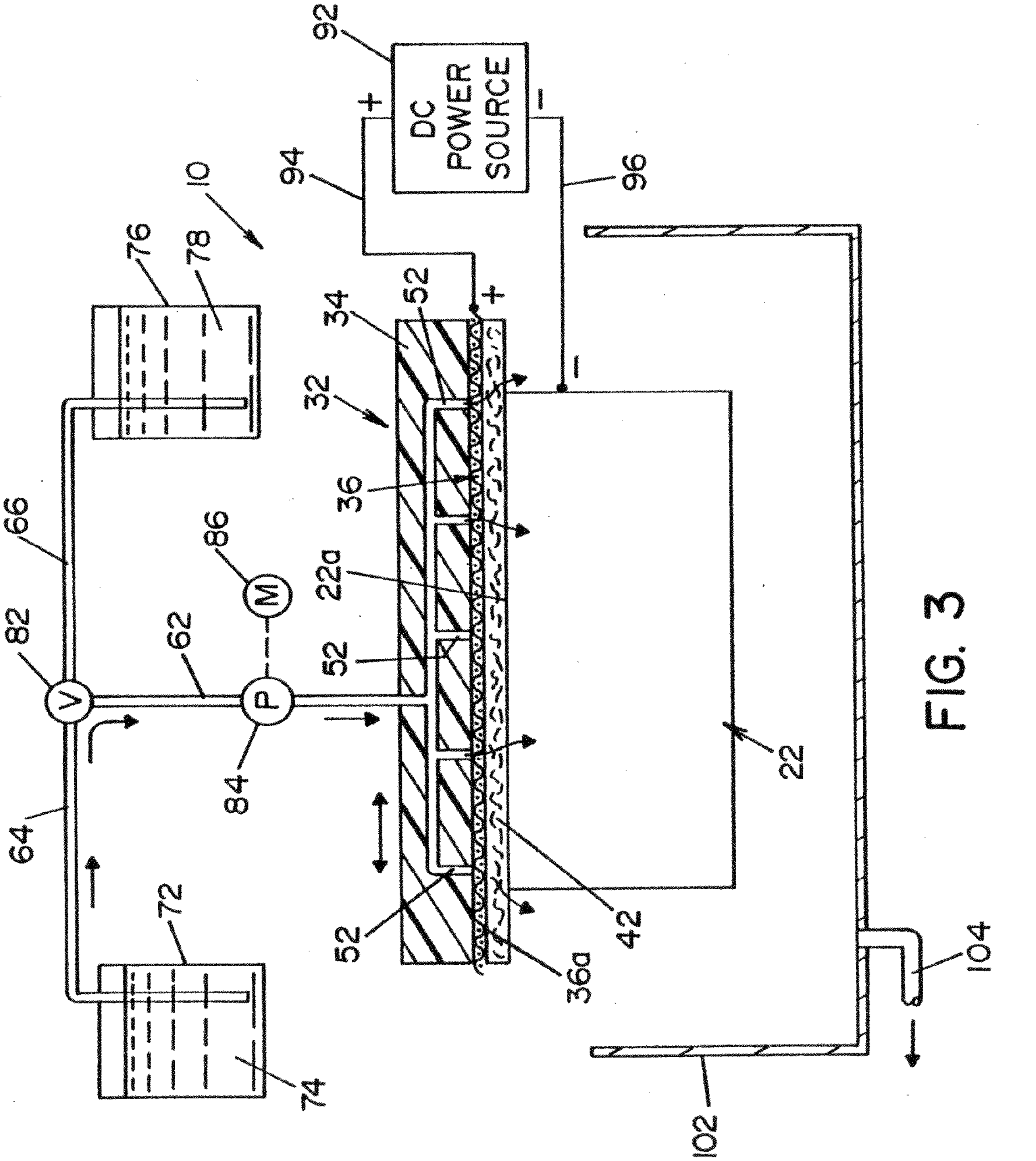
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FIG. 3

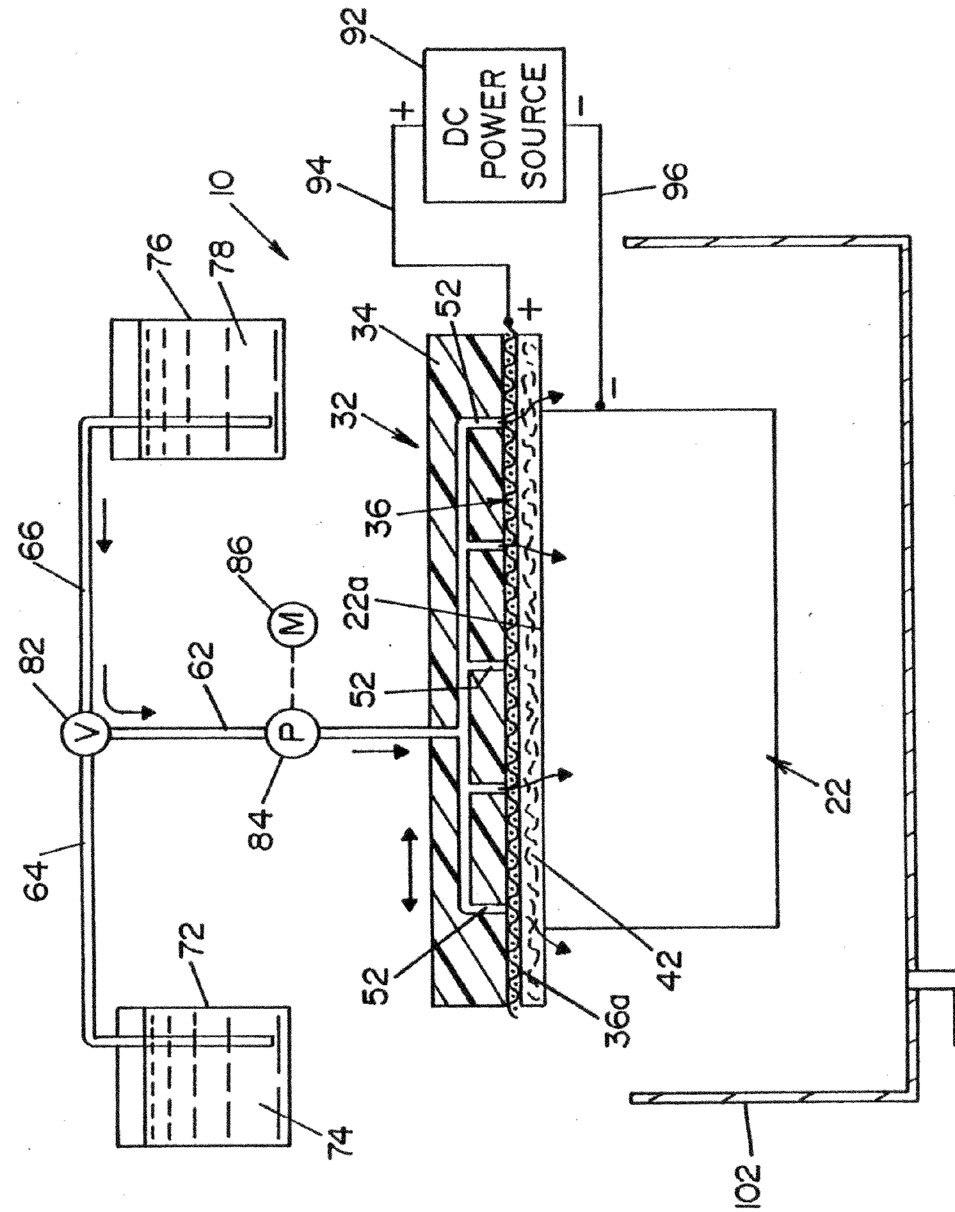
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FIG. 4

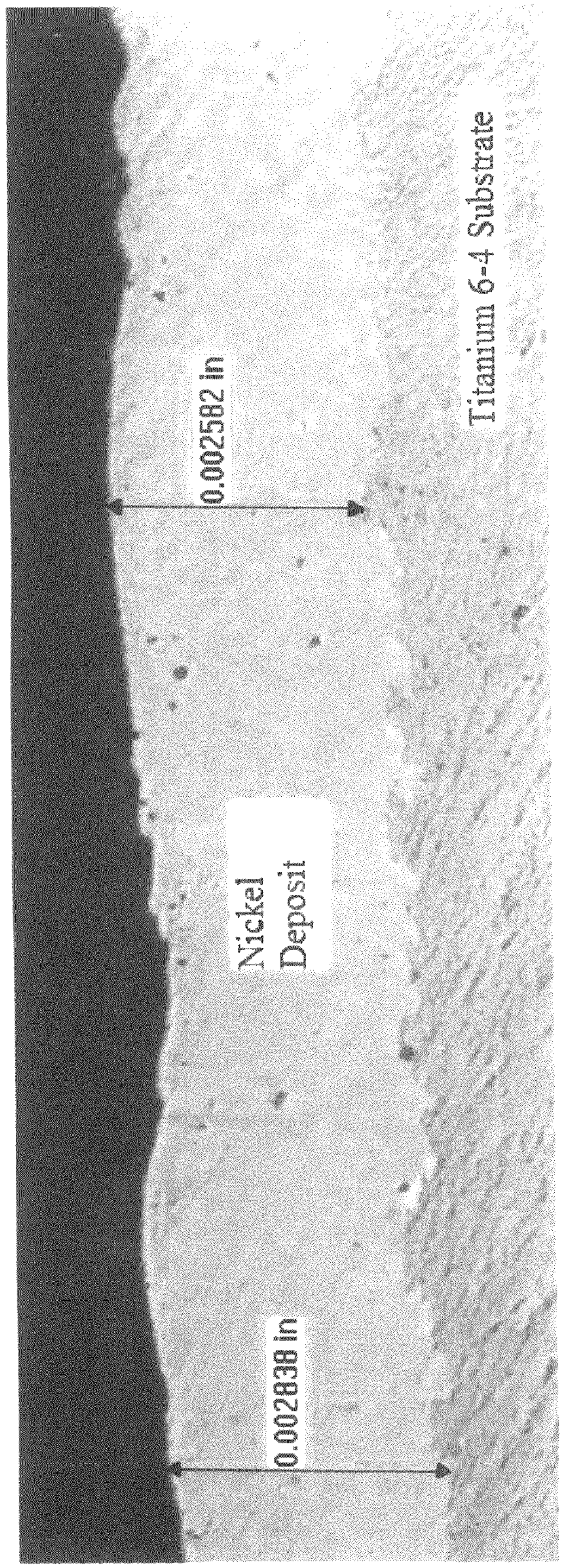
Titanium 6-4 Substrate
0.002582 in
Nickel Deposit
0.002838 in

FIG. 5

METHOD OF PLATING METAL ONTO TITANIUM

FIELD OF THE INVENTION

[0001] The present invention relates to the art of plating, and more particularly to a method of electroplating a metal or metal alloy onto titanium.

BACKGROUND OF THE INVENTION

[0002] Because of its high strength and low weight, titanium finds advantageous use in many applications in the aerospace, industrial, and medical fields. The strength, hardness, and working temperature of titanium can further be improved by alloying. An alloy of titanium that is easily available and widely used is 6-4 Titanium (also referred to as "Grade 5 titanium"). 6-4 Titanium consists of 6% by weight aluminum, 4% by weight vanadium and the balance being titanium.

[0003] Despite the aforementioned properties, titanium and titanium alloys have found little use in mechanical engineering applications because of their poor tribological properties, namely, poor abrasive wear resistance, poor fretting behavior and high coefficient of friction. These tribological properties relate generally to the tenacious, compact oxide film that readily forms on the surface of titanium. In this respect, titanium is intrinsically very reactive. Whenever the metal is exposed to air or any environment containing available oxygen, the oxide film is formed on the surface thereof. The tribological performance can be improved by applying surface treatments and coatings. Coatings on titanium are also applied for the purposes of heat reflection, emissivity, corrosion resistance in hot acidic environments, conductivity, lubricity, brazing, and resizing.

[0004] Electrodeposition is an effective method for applying a coating onto a metal. Preparation of the surface of a titanium part is key to achieving robust adhesion between the titanium and any coating applied thereto.

[0005] In order for an electrodeposited coating to have optimal adhesion to titanium, the aforementioned oxide layer should be removed. However, the tenacity of the oxide layer makes its removal problematic. A common method to remove oxide from titanium is by exposure to a fluoride containing electrolyte. However, the toxicity and health hazards associated with fluoride makes such an oxide-removal process undesirable. The rapidity with which the oxide reforms after removal is also a factor to be considered with respect to this method.

[0006] Another factor that affects adhesion between two materials is surface area. Surface roughening of titanium is typically carried out by abrasion, grit blasting, and etching. However, as with fluoride cleaning, oxide quickly reforms on the surface of titanium following these cleaning processes and reduces adhesion. In other words, once the area to be plated has been dry-blasted or cleaned using hydrofluoric acid, steps must be taken to prevent titanium oxide from reforming on the surface of the part prior to a plating process.

[0007] The present invention overcomes these and other problems and provides a brush plating process for plating metal onto titanium.

SUMMARY OF THE INVENTION

[0008] In accordance with a preferred embodiment of the present invention, there is provided a method of plating a metal onto a titanium surface, comprising the steps of:

[0009] (a) positioning an electrode adjacent to a titanium surface, the electrode having an electrode surface conforming to the shape of the titanium surface and having a porous, abrasive pad positioned thereon, the pad on the electrode being in contact with the titanium surface, wherein an interface is defined between the pad and the titanium surface and wherein the pad defines a gap between the titanium surface and the electrode surface;

[0010] (b) etching the titanium surface by applying a positive voltage to the titanium surface and a negative voltage to the electrode while maintaining the relative movement between the titanium surface and the pad and maintaining the wetting of the interface between the pad and the titanium surface with the etching solution;

[0011] (c) activating the titanium surface by applying a negative voltage to the titanium surface and a positive voltage to the electrode while maintaining the wetting of the interface between the pad and the titanium surface with the etching solution and maintaining the relative movement between the titanium surface and the pad; and

[0012] (d) plating a metal onto the titanium surface by applying a plating solution to the interface between the pad and the titanium surface while applying a negative voltage to the titanium surface and a positive voltage on the electrode, and while maintaining the relative movement between the titanium surface and the pad, said pad maintaining complete coverage of said titanium surface during said abrading step, said etching step, said activating step and said plating step.

[0013] In accordance with another embodiment of the present invention, there is provided a method of plating a surface of a first metal with a second metal, comprising the steps of:

[0014] (a) positioning an electrode adjacent to a surface of a first metal, the electrode having a porous, abrasive pad positioned thereon, the pad on the electrode completely covering, and being in contact with, the surface of the first metal, wherein an interface is defined between the pad and the surface of the first metal and wherein the pad defines a gap between the surface of the first metal and the electrode surface;

[0015] (b) etching the surface of the first metal by applying a positive voltage to the surface of the first metal and a negative voltage to the electrode while maintaining the relative movement between the surface of the first metal and the pad and maintaining the wetting of the interface between the pad and the surface of the first metal with the etching solution;

[0016] (c) activating the surface of the first metal by applying a negative voltage to the surface and a positive voltage to the electrode while maintaining the wetting of the interface between the pad and the surface of the first metal with the etching solution and maintaining the relative movement between the surface of the first metal and the pad; and

[0017] (d) plating a second metal onto the surface of the first metal by applying a plating solution to the interface between the pad and the surface of the first metal while applying a negative voltage to the surface of the first metal and a positive voltage on the electrode, and while maintaining the relative movement between the surface of the first metal and the pad, the pad maintaining complete coverage of the surface of the first metal during the abrading step, the etching step, the activating step and the plating step.

[0018] In accordance with yet another embodiment of the present invention, there is provided a system for plating a metal onto a titanium surface. An electrode is dimensioned to be disposed adjacent to a titanium surface. The electrode has an electrode surface dimensioned to conform to the shape of the titanium surface. A porous abrasive pad is disposed on the electrode surface. The pad is dimensioned to cover and contact the titanium surface, such that the pad defines a gap between the electrode and the titanium surface. A selective means is provided for selectively supplying an etching solution and a plating solution to the gap between the electrode and the titanium surface such that the titanium surface is covered by the etching solution or the plating solution when the titanium surface is plated and the pad and the titanium surface continuously move relative to each other when the titanium surface is abraded, etched, activated, and plated.

[0019] An advantage of the present invention is a method of plating a metal onto a titanium part.

[0020] Another advantage of the present invention is a method of electroplating nickel onto a titanium alloy.

[0021] Another advantage of the present invention is a method of applying a metal to a titanium alloy using a selective, brush-plating process.

[0022] A still further advantage of the present invention is a method of plating as described above that does not use hydrofluoric acid to remove titanium oxide from the surface of the titanium part to be plated.

[0023] Another advantage of the present invention is a method of plating as described above that does not require a dry or wet blasting to prepare the surface of the titanium part to be plated.

[0024] These and other advantages will become apparent from the following description of a preferred embodiment taken together with the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The invention may take physical form in certain parts and arrangement of parts, a preferred embodiment of which will be described in detail in the specification and illustrated in the accompanying drawings which form a part hereof, and wherein:

[0026] FIG. **1** is a schematic view of an apparatus for plating metal onto a titanium work piece, illustrating an abrading step in a plating process according to the present invention;

[0027] FIG. **2** is a schematic view of the plating apparatus shown in FIG. **1** showing an etching step in a plating process;

[0028] FIG. **3** is a schematic view of the plating apparatus shown in FIG. **1** showing an activating step in a plating process;

[0029] FIG. **4** is a schematic view of the plating apparatus shown in FIG. **1** showing a plating step in a plating process; and

[0030] FIG. **5** is a photomicrograph showing a cross-sectional view of a nickel coating on a titanium surface, formed according to the process schematically illustrated in FIGS. **1-4**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

[0031] Referring now to the drawings wherein the showings are for the purpose of illustrating a preferred embodiment of the invention only, and not for the purpose of limiting same, FIG. **1** schematically illustrates an apparatus **10** for brush plating a metal onto a titanium work piece **22**. Brush plating is a metallization technique which utilizes a small volume of solution contained in a fabric matrix between the anode and cathode in a plating cell. The small volume of solution and proximity of an anode and cathode enables procedures and techniques to be utilized which are impractical with other electroplating or coating methods.

[0032] The present invention shall be described with respect to plating nickel (Ni) onto titanium. However, as will be appreciated by those skilled in the art after reading the specification and claims, the present invention may find advantageous application in plating other metals onto titanium or onto other metals that exhibit similar surface oxidation characteristics. As used herein, the term “titanium” shall refer to titanium and titanium alloys where titanium is the major component.

[0033] FIG. **1** shows a rectangular, titanium work piece **22** having a planar, upper surface **22*a*** to be plated. An electrode assembly **32** is disposed above surface **22*a***. Electrode assembly **32** is comprised of a support block **34** having an electrode **36** attached to the lower surface thereof. Electrode **36** has an electrode surface **36*a*** that is shaped to conform to surface **22*a*** to be plated. In the embodiment shown, electrode surface **36*a*** is planar to match planar surface **22*a*** of work piece **22**. In the embodiment shown, support block **34** is rectangular in shape and is formed of a non-conductive polymer material, such as by way of example and not limitation, polypropylene. Electrode **36** is comprised of a sheet of titanium mesh that is plated with a noble metal.

[0034] As illustrated in FIG. **1**, electrode assembly **32**, i.e., support block **34** and electrode **36**, is larger than surface **22*a*** to be plated. As shall be described in greater detail below, electrode assembly **32** is designed such that electrode assembly **32** and surface **22*a*** can move relative to each other with electrode assembly **32** maintaining constant contact with surface **22*a*** of work piece **22**.

[0035] A brush, or pad **42**, is disposed between surface **22*a*** of work piece **22** and surface **36*a*** of electrode **36**. As shall be described in greater detail below, pad **42** basically forms a uniform gap between surface **22*a*** of work piece **22** and surface **36*a*** of electrode **36**. Pad **42** is formed of a fibrous, porous material.

[0036] A plurality of fluid supply channels **52** are formed in support block **34**. Channels **52** communicate with the lower surface of support block **34** to conduct fluid to electrode **36** and to brush pad **42**, as shall be described in greater detail below. A fluid conduit **62** communicates with fluid channels **52**. A first branch conduit **64** connects fluid conduit **62** to a source **72** of an acidic, etching solution **74**. A second branch conduit **66** connects fluid conduit **62** to a source **76** of a metal plating solution **78**. A valve **82** is disposed at the junction where fluid conduit **62** joins first and second branch conduits **64**, **66**. Valve **82** is operable to control the flow of solution through fluid conduit **62**. A pump **84** is provided in fluid conduit **62** to pump either etching solution **74** or plating solution **78** from the respective sources **72**, **76**, based on the position of valve **82**. A motor **86** is provided to drive pump **84**.

[0037] An electrical power source **92** has a first lead **94** that is electrically connected to electrode **36**. A second lead **96** extends from power source **92** and is electrically connected to titanium work piece **22**.

[0038] As schematically illustrated in FIG. **1**, a tank or tray **102** is disposed beneath work piece **22** to collect etching solution **74** and plating solution **78**, as shall be described in greater detail below. A drain line **104** is provided at the bottom of tank **102** to direct etching solution **74** and/or plating solution **78** to a location (not shown) for recycling.

[0039] The present invention shall now further be described with regard to a method of plating nickel onto titanium. Broadly stated, the method of electroplating nickel onto titanium comprises a surface cleaning step, an anodic etching step, a cathodic activation step and a plating step.

[0040] FIG. **1** schematically illustrates a surface cleaning step. Basically, surface area **22***a* to be plated is abraded to remove surface oxide therefrom. Pad **42**, that is attached to electrode **36**, is brought into contact with surface **22***a* of work piece **22**. Pad **42** establishes a generally uniform gap or spacing between surface **36***a* of electrode **36** and surface **22***a* of work piece **22**. In this respect, the thickness of pad (brush) **42** essentially establishes the thickness of the gap. In a preferred embodiment, the gap between electrode **36** and work piece **22** is about 5 mm.

[0041] In accordance with the present invention, pad **42** and surface **22***a* are moved relative to each other. In other words, pad **42** is "brushed" across surface **22***a* to be plated. As used herein, the term "brushed" refers to moving electrode **36** (having pad **42** on surface **36***a* thereof) over surface **22***a*. In a preferred embodiment, work piece **22** is stationary, and electrode **36** with brush pad **42** is reciprocally moved relative thereto. It is also contemplated that electrode **36** with brush pad **42** can remain stationary, while work piece **22** is moved relative thereto.

[0042] As indicated above, the cleaning step is intended to remove surface oxides from work piece **22**. Accordingly, brush pad **42** is formed of a porous, abrasive material, such as by way of example and not limitation, nylon, Dacron and cotton gauze. In one embodiment, brush pad **42** is comprised of a 3M Scotch-Brite® abrasive pad. An initial period of the surface cleaning step may be comprised of surface **22***a* of work piece **22** being scoured and abraded by a dry brush pad **42**. Preferably, the scouring and abrading of surface **22***a* occurs while an etching solution is introduced at the interface between brush pad **42** and work piece **22**. FIG. **1** schematically illustrates introducing etching solution **74** to the surface of work piece **22** while brush pad **42** is moved thereacross. In this respect, valve **82** is moved to a first position where branch conduit **64** is in fluid communication with fluid line **62** and channel passages **52** in electrode assembly **32**. When valve **82** is in this position, flow of plating solution **78** from source **76** is prevented. Motor **86** is energized to cause pump **84** to pump etching solution **74** through support block **34**, electrode **36** and brush pad **42** to surface **22***a* of work piece **22**. Pump **84** is dimensioned to maintain sufficient flow to maintain surface **22***a* immersed in etching solution **74**. Etching solution **74** flowing off work piece **22** is collected by tank **102**.

[0043] Etching solution **74** is basically an acid solution that, together with the scouring of surface **22***a* caused by the reciprocal motion of brush pad **42** thereon, removes the surface oxidation from surface **22***a*. As shall be described in greater detail below, acidic etching solution **74** preferably contains a small amount of plating solution. The continuous contact of brush pad **42** against surface **22***a* and the presence of liquid etching solution **74** within pad **42**, basically prevent or significantly retard the reformation of surface oxidation on surface **22***a* of titanium work piece **22**.

[0044] Following the aforementioned surface cleaning step, an anodic etch step is performed. During this step, the flow of etching solution **74** to surface **22***a* and the "brushing" movement of electrode assembly **32** relative to work piece **22** is maintained. During the anodic etch step, a positive voltage is applied by power source **92** to titanium work piece **22** and a negative voltage is applied to electrode **36**, as illustrated in FIG. **2**. An electrical potential on surface **22***a* enhances the etching effects of etching solution **74** on surface **22***a* as surface atoms of titanium and titanium oxide are released from surface **22***a*. The result of the anodic etch step is to remove small amounts of the titanium surface from surface **22***a* of work piece **22**.

[0045] Following the anodic etch step, a cathodic activation step is performed using etching solution **74**. During this step, electrode **36** and brush (pad) **42** continuously move across surface **22***a* to be plated, and etching solution **74** is continuously applied to surface **22***a* through electrode assembly **32**. The polarity of the voltage across electrode **36** and work piece **22** is reversed, such that a negative voltage is applied to work piece **22** and a positive voltage is applied to electrode **36**. The reversal of the voltage activates surface **22***a* of titanium work piece **22**. The electrical potential on surface **36***a* of electrode **36** creates a current density on surface **22***a*. As indicated above, etching solution **74** preferably includes a small amount of plating solution **78**. The metal ions in plating solution **78** and etching solution **74** plate minute amounts of metal onto surface **22***a*. FIG. **3** schematically illustrates the cathodic activation steps.

[0046] Following the cathodic activation step, a metal plating step is performed. During the metal plating step, valve **82** is moved to a second position wherein second branch conduit **66** communicates with fluid conduit **62** to electrode assembly **32** and is pumped thereto by pump **84**. Movement of valve **82** to its second position prevents further flow of etching solution **74** to electrode assembly **32**. A plating solution **78** is applied to surface **22***a* of work piece **22** while brush pad **42** is continuously brushed across surface **22***a*. The voltage to electrode **36** and work piece **22** is increased to a desired plating level to establish a desired current density along surface **22***a*. As illustrated in FIG. **4**, a positive voltage is applied to electrode **36** and a negative voltage is applied to work piece **22**. The voltage is maintained across electrode **36** and work piece **22** until a desired thickness of nickel is built up onto surface **22***a* of titanium work piece **22**.

[0047] Throughout the foregoing process, brush pad **42** and a solution, either etching solution **74** or plating solution **78**, is always in contact with surface **22***a* of titanium work piece **22** throughout the process. In this respect, the movement of brush pad **42** and the continuous flow of a solution across surface **22***a*, in addition to surface **22***a* being kept under electrical potential control, prevents oxide from reforming onto surface **22***a*. This allows the nickel to be applied to titanium work piece **22** without a titanium oxide layer (that would form if titanium work piece **22** was exposed to oxygen) from interfering with the plating process.

[0048] As will be appreciated from the foregoing, it is necessary that brush pad **42** and solutions **74**, **78** cover the entire surface **22***a*, and the same be maintained in contact with surface **22***a* throughout the plating process.

EXAMPLE I

[0049] Using the foregoing process, nickel is brush plated onto a sheet of 6-4 Titanium. The titanium is kept under an electrical potential at all times following the initial surface cleaning step. The plated area is 100% covered by the brush pad **42**, and the electrical potential is rapidly switched from anodic to cathodic. No rinsing occurs between steps, and the etching and plating solutions are not reused.

[0050] The process for producing nickel coatings on 6-4 Titanium is as follows:

Step	Operation	Material	Conditions
1	Abrading step	Red Scotch Brite	Wet with etching solution
2	Etching step	Etching solution	Wet with etching solution, 14 V anodic, 10 seconds
3	Activation step	Etching solution	Wet with etching solution, 4-8 V cathodic, 1 minute
4	Plating step	Plating solution	Wet with plating solution, 8-18 V cathodic, 0.078 A * hr/cm^2

[0051] The etching solution is comprised of 10% NaCl, 7% HCl, 1% Ni salts, 0.3% citric acid by weight. The plating solution is comprised of an acid nickel sulfate solution sold under the trade name SIFCO 2080/5600, manufactured by SIFCO Applied Surface Concepts, 5708 E. Schaaf Road, Independence, Ohio 44131 U.S.A. A SIFCO Model No. SPL-75 rectifier, capable of rapid switching between cathodic and anodic modes, is used.

[0052] Adhesion of the plated metal to the titanium substrate is tested following the procedures given in Aerospace Material Specification AMS 2451A and ASTM B571. Adhesion is evaluated using the chisel-knife, tape, and bend tests. The titanium sheets are bent 180° around a diameter equal to the thickness of the sheet in the bend test. The tape is pulled with a quick motion at a 180° angle to the surface. A sharp cold chisel is used to penetrate the coating. The results of a test are considered "good" if no separation of the plated metal from the base metal occurs. The interface between titanium and plating is examined in cross-section.

[0053] The aforementioned test provides good nickel deposit adhesion with 6-4 Titanium and Titanium 6-6-2 (6A1-6V-2Sn) alloys.

[0054] FIG. **5** shows a cross-section of a brush plated nickel coating on a sheet of 6-4 Titanium. The interface between the titanium and nickel is free of the bulk oxide. FIG. **5** shows that the smooth surface of the original titanium was microetched during pretreatment. Nickel plated readily into the microroughened surface of the titanium. The adhesion is checked by the aforementioned tape and bend tests.

[0055] It is believed that several factors contribute to the excellent adhesion exhibited by the structure in FIG. **5**, namely, mechanical interlocking, increased surface area, and lack of an oxide film. These three attributes are generated during the brush plating process. Brush plating is particularly suited for generating these three attributes due to (1) the small volumes of electrolyte used, (2) the close contact between the anode and the cathode, and (3) the rapidity with which electrolytes can be switched from activation to strike plating.

[0056] The foregoing description is a specific embodiment of the present invention. It should be appreciated that this embodiment is described for purposes of illustration only, and that numerous alterations and modifications may be practiced by those skilled in the art without departing from the spirit and scope of the invention. For example, while the present invention has been described with respect to plating nickel onto titanium, it will be appreciated that the present invention may find advantageous application in plating other metals onto metals having oxide surface coatings. Moreover, while the invention has been described with respect to plating metal onto a planar surface, it will be appreciated by those skilled in the art that the disclosed process may be used in plating internal and external diameters. It is intended that all such modifications and alterations be included insofar as they come within the scope of the invention as claimed or the equivalents thereof.

Having described the invention, the following is claimed:

1. A method of plating a metal onto a titanium surface, comprising the steps of:

(a) positioning an electrode adjacent to a titanium surface, said electrode having an electrode surface conforming to the shape of said titanium surface and having a porous, abrasive pad positioned thereon, said pad on said electrode completely covering, and being in contact with, said titanium surface, wherein an interface is defined between said pad and said titanium surface and wherein said pad defines a gap between said titanium surface and said electrode surface;

(b) etching said titanium surface by applying a positive voltage to said titanium surface and a negative voltage to said electrode while maintaining said relative movement between said titanium surface and said pad and maintaining said wetting of said interface between said pad and said titanium surface with said etching solution;

(c) activating said titanium surface by applying a negative voltage to said titanium surface and a positive voltage to said electrode while maintaining said wetting of said interface between said pad and said titanium surface with said etching solution and maintaining said relative movement between said titanium surface and said pad; and

(d) plating a metal onto said titanium surface by applying a plating solution to said interface between said pad and said titanium surface while applying a negative voltage to said titanium surface and a positive voltage on said electrode, and while maintaining said relative movement between said titanium surface and said pad, said pad maintaining complete coverage of said titanium surface during said abrading step, said etching step, said activating step and said plating step.

2. A method as defined in claim **1**, wherein said etching solution and said plating solution flow through said electrode and through said pad.

3. A method as defined in claim **1**, further comprising a support block disposed above said electrode.

4. A method as defined in claim **3**, wherein said support block is comprised of a polymer material.

5. A method as defined in claim **3**, wherein said support block includes a plurality of fluid supply channels formed therein, wherein said fluid supply channels fluidly communicate with a source of said etching solution and a source of said plating solution.

6. A method as defined in claim **5**, further comprising a valve operable to selectively connect said fluid supply channels to said source of said etching solution and said source of said plating solution.

7. A method as defined in claim **1**, wherein said titanium surface is stationary.

8. A method as defined in claim **1**, wherein said titanium surface is planar.

9. A method as defined in claim **1**, wherein said titanium surface is a non-planar surface.

10. A method as defined in claim **1**, wherein said pad is made from a material selected from the group consisting of nylon, Dacron and cotton gauze.

11. A method as defined in claim **1**, wherein said etching solution is an acid solution.

12. A method as defined in claim **11**, wherein said etching solution contains about 10% NaCl, about 7% HCl, about 1% Ni salts and about 0.3% citric acid by weight.

13. A method as defined in claim **1**, wherein said plating solution is comprised of an acid nickel sulfate solution.

14. A method as defined in claim **1**, further comprising a step of:

abrading said titanium surface by producing relative movement between said titanium surface and said pad while simultaneously wetting said interface between said pad and said titanium surface with an etching solution, said abrading step preceding said etching step.

15. A method of plating a surface of a first metal with a second metal, comprising the steps of:

(a) positioning an electrode adjacent to a surface of a first metal, said electrode having a porous, abrasive pad positioned thereon, said pad on said electrode completely covering, and being in contact with, said surface of said first metal, wherein an interface is defined between said pad and said surface of said first metal and wherein said pad defines a gap between said surface of said first metal and said electrode surface;

(b) etching said surface of said first metal by applying a positive voltage to said surface of said first metal and a negative voltage to said electrode while maintaining said relative movement between said surface of said first metal and said pad and maintaining said wetting of said interface between said pad and said surface of said first metal with said etching solution;

(c) activating said surface of said first metal by applying a negative voltage to said surface and a positive voltage to said electrode while maintaining said wetting of said interface between said pad and said surface of said first metal with said etching solution and maintaining said relative movement between said surface of said first metal and said pad; and

(d) plating a second metal onto said surface of said first metal by applying a plating solution to said interface between said pad and said surface of said first metal while applying a negative voltage to said surface of said first metal and a positive voltage on said electrode, and while maintaining said relative movement between said surface of said first metal and said pad, said pad maintaining complete coverage of said surface of said first metal during said abrading step, said etching step, said activating step and said plating step.

16. A method as defined in claim **15**, wherein said electrode has a surface conforming to the shape of said surface of said first metal.

17. A method as defined in claim **15**, wherein said etching solution and said plating solution flow through said electrode and through said pad.

18. A method as defined in claim **15**, further comprising a support block disposed above said electrode.

19. A method as defined in claim **18**, wherein said support block is comprised of a polymer material.

20. A method as defined in claim **18**, wherein said support block includes a plurality of fluid supply channels formed therein, wherein said fluid supply channels fluidly communicate with a source of said etching solution and a source of said plating solution.

21. A method as defined in claim **15**, further comprising a valve operable to selectively connect said fluid supply channels to said source of said etching solution and said source of said plating solution.

22. A method as defined in claim **15**, wherein said first metal is a quickly oxidizing metal.

23. A method as defined in claim **22**, wherein said first metal is titanium.

24. A method as defined in claim **22**, wherein said first metal is a titanium alloy.

25. A method as defined in claim **24**, wherein said second metal is nickel.

26. A method as defined in claim **15**, wherein said pad is made from a material selected from the group consisting of nylon, Dacron and cotton gauze.

27. A method as defined in claim **15**, wherein said etching solution is an acid solution.

28. A method as defined in claim **27**, wherein said etching solution contains about 10% NaCl, about 7% HCl, about 1% Ni salts and about 0.3% citric acid by weight.

29. A method as defined in claim **15**, wherein said plating solution is comprised of an acid nickel sulfate solution.

30. A method as defined in claim **15**, further comprising a step of:

abrading said surface of said first metal by producing relative movement between said surface of said first metal and said pad while simultaneously wetting said interface between said pad and said surface of said first metal with an etching solution, said abrading step preceding said etching step.

31. A system for plating a metal onto a titanium surface comprised of:

an electrode dimensioned to be disposed adjacent to a titanium surface, said electrode having an electrode surface dimensioned to conform to the shape of said titanium surface;

a porous abrasive pad disposed on said electrode surface, said pad dimensioned to cover and contact said titanium surface, such that said pad defines a gap between said electrode and said titanium surface; and

selective means for selectively supplying an etching solution and a plating solution to said gap between said electrode and said titanium surface such that said titanium surface is covered by said etching solution or said plating solution when said titanium surface is plated and said pad and said titanium surface continuously move relative to each other when said titanium surface is abraded, etched, activated, and plated.

32. A system as defined in claim **31**, further comprising:

a support block disposed above said electrode, said support block including a plurality of fluid supply channels formed therein, said fluid supply chains fluidly communicating with a source of said etching solution and a source of said plating solutions.

33. A system as defined in claim **32**, wherein said selective means is a valve operable to selectively connect said fluid supply channels to said source of said etching solution and said source of said plating solution.

34. A system as defined in claim **31**, wherein said pad is made from a material selected from the group consisting of nylon, Dacron and cotton gauze.

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