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(54) **ELECTROLESS GOLD PLATING BATH**

(57) An electroless gold plating bath is presented, which is capable of forming a uniform gold plating film with a sufficient thickness in one step in both the ENIG process and the ENEPIG process.

The electroless gold plating bath includes a gold sulfite, a thiosulfate, ascorbic acid compounds, and hydrazine compounds, the hydrazine compounds being at least one selected from the group consisting of adipic

dihydrazide, propionic hydrazide, hydrazine sulfate, hydrazine monohydrochloride, hydrazine dihydrochloride, hydrazine carbonate, hydrazine monohydrate, sebacic dihydrazide, dodecanediohydrazide, isophthalic dihydrazide, salicylic hydrazide, 3-hydro-2-naphthoic hydrazide, benzophenone hydrazone, phenylhydrazine, benzylhydrazine monohydrochloride, methylhydrazine sulfate, and isopropylhydrazine hydrochloride.

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Description**BACKGROUND**

5 **[0001]** The present disclosure relates to an electroless gold plating bath.

[0002] Gold has high electrical conductivity next to silver and copper, and is excellent in physical properties such as connectivity in thermocompression bonding, and is also excellent in chemical properties such as oxidation resistance and chemical resistance. Therefore, gold plating with gold is widely used as a final surface treatment method for circuits on printed wiring boards, mounting portions and terminal portions of IC packages, and the like in the field of the electronics industry. In recent years, along with the improvement of electronic components to be smaller and denser, electroless plating methods attaining excellent functionality without the need of lead wiring have been used preferably.

10 **[0003]** One example of such an electroless plating method thus used is an Electroless Nickel Immersion Gold (ENIG) process. By using the ENIG process, a plating film sequentially including an electroless nickel plating film and a substitution gold plating film can be obtained. Moreover, for example, an Electroless Nickel Electroless Palladium Immersion Gold (ENEPIG) process has been also used as such an electroless plating method. By using the ENEPIG process, a plating film sequentially including an electroless nickel plating film, an electroless palladium plating film, and a substitution gold plating film can be obtained.

15 **[0004]** As a reduction substitution type electroless gold plating bath used in these electroless plating methods, for example, an electroless gold plating bath has been proposed, which contains a water-soluble gold compound, a complexing agent, and a reducing agent as well as polyvinyl alcohol and/or polyvinylpyrrolidone added as a stabilizer. It is described that such a configuration makes it possible to form a good gold plating film only in metal portions and is preferably applicable to gold plating for ceramics IC, packages, and the like (For example, see Japanese Patent No.2927142).

SUMMARY

25 **[0005]** In the known electroless gold plating bath described above, it is difficult to deposit gold on the palladium plating film, so that formation of the gold plating film would be insufficient in minute portions such as terminal portions, thereby leading to difficulty in forming a uniform gold plating film.

30 **[0006]** Moreover, in order to form a gold plating film with a sufficient thickness (thickness of 0.1 μm or thicker) on the nickel plating film, there has arisen the following problem: It is necessary to form the electroless gold plating film with the electroless gold plating bath after the formation of the substitution gold plating film on a plating object, so that the gold plating needs to be performed in two steps.

35 **[0007]** In view of the problems described above, an object of the present disclosure is to provide an electroless gold plating bath, which is capable of forming a uniform gold plating film with a sufficient thickness in one step in both the ENIG process and the ENEPIG process.

40 **[0008]** In order to attain the object, the electroless gold plating bath of the present disclosure includes a gold sulfite, a thiosulfate, ascorbic acid compounds, and hydrazine compounds, the hydrazine compounds being at least one selected from the group consisting of adipic dihydrazide, propionic hydrazide, hydrazine sulfate, hydrazine monohydrochloride, hydrazine dihydrochloride, hydrazine carbonate, hydrazine monohydrate, sebacic dihydrazide, dodecanediohydrazide, isophthalic dihydrazide, salicylic hydrazide, 3-hydro-2-naphthoic hydrazide, benzophenone hydrazone, phenylhydrazine, benzylhydrazine monohydrochloride, methylhydrazine sulfate, isopropylhydrazine hydrochloride, 1,1-dimethylhydrazine, 2-hydrazinobenzothiazole, acetohydrazide, 2-hydroxyethylhydrazine, ethoxycarbonylhydrazine, methoxycarbonylhydrazine, phenylhydrazine-4-sulfonic acid, and benzohydrazide.

45 **[0009]** According to the present disclosure, it becomes possible to provide an electroless gold plating bath, which is capable of forming a uniform gold plating film with a sufficient thickness in one step in both the ENIG process and the ENEPIG process.

DETAILED DESCRIPTION

50 **[0010]** In the following, an electroless gold plating bath of the present disclosure will be described.

<Electroless Gold Plating Bath>

55 **[0011]** The electroless gold plating bath of the present disclosure is an electroless gold plating bath including a gold sulfite as a gold source, a thiosulfate as a complexing agent, ascorbic acid compounds as a reducing agent, and hydrazine compounds as a reducing agent.

(Gold Sulfite)

[0012] The electroless gold plating bath of the present disclosure is a cyanide-free bath (non-cyanide bath), and includes, as the gold source, gold sulfite (e.g., sodium gold sulfite), which is a water-soluble gold compound with no cyano group.

[0013] The concentration of the gold sulfite in the plating bath may be preferably 0.5 g/L to 2 g/L based on gold. A concentration of the gold sulfite of less than 0.5 g/L would result in a low plating deposition rate, while a concentration of the gold sulfite of more than 2 g/L would result in a poor adhesion of the gold plating film to the electroless nickel plating film.

(Complexing Agent)

[0014] The complexing agent is used to stabilize the solubility of gold in the electroless gold plating bath. The electroless gold plating bath of the present disclosure includes a sulfur compound as the complexing agent. The sulfur compound may be a thiosulfate (such as sodium thiosulfate, potassium thiosulfate, ammonium thiosulfate, or the like) a sulfite (such as sodium sulfite, potassium sulfite, ammonium sulfite, or the like). These complexing agents may be used solely, or a combination of two or more thereof may be used.

[0015] Moreover, the concentration of the thiosulfate (which may be thiosulfates) in the plating bath may be in a range of 0.5 g/L to 10 g/L, preferably. If the concentration of the thiosulfate is less than 0.5 g/L, the effect of the complexing agent would be insufficient, and if the concentration of the thiosulfate is greater than 10 g/L, local corrosion of the electroless nickel plating film would be increased, which would cause a gap between the corroded portion of the electroless nickel plating film and the electroless gold plating film, thereby reducing adhesion of the gold plating film to the electroless nickel plating film.

[0016] From the viewpoint of suppressing the decrease in adhesion of the gold plating film to the electroless nickel plating film and suppressing the corrosion on the surfaces of the electroless nickel plating film and electroless palladium plating film, it is preferable that a mass ratio of gold in the gold sulfite to thiosulfate be gold: thiosulfate = 1: 0.5 to 1: 10.

(Reducing Agent)

[0017] The reducing agent is used to reduce the gold sulfite, which is the gold source, in order to precipitate gold. In the electroless gold plating bath of the present disclosure, the reducing agent includes hydrazine compounds and ascorbic acid compounds in combination used at once.

[0018] The hydrazine compounds are for facilitating the formation of the gold plating film on the nickel plating film or the palladium plating film, especially for facilitating the formation of the gold plating film on the palladium plating film in the ENEPIG process.

[0019] Examples of the hydrazine compounds include adipic dihydrazide, propionic hydrazide, hydrazine sulfate, hydrazine monohydrochloride, hydrazine dihydrochloride, hydrazine carbonate, hydrazine monohydrate, sebacic dihydrazide, dodecanediohydrazide, isophthalic dihydrazide, salicylic hydrazide, 3-hydro-2-naphthoic hydrazide, benzophenone hydrazone, phenylhydrazine, benzylhydrazine monohydrochloride, methylhydrazine sulfate, isopropylhydrazine hydrochloride, 1,1-dimethylhydrazine, 2-hydrazinobenzothiazole, acetohydrazide, 2-hydroxyethylhydrazine, ethoxycarbonylhydrazine, methoxycarbonylhydrazine, phenylhydrazine-4-sulfonic acid, benzohydrazide, and the like. These hydrazine compounds may be used solely, or a combination of two or more thereof may be used.

[0020] Moreover, the concentration of the hydrazine compound (which may be hydrazine compounds) in the plating bath may be in a range of 0.5 g/L to 15 g/L, preferably. If the concentration of the hydrazine is less than 0.5 g/L, a plating rate would become insufficient. Moreover, in general, the plating rate is increased proportionally to the concentration of the reducing agent. However, if the concentration of the hydrazine is greater than 15 g/L, the plating rate would not be improved so significantly regardless of the concentration, while bath stability of the plating bath would be deteriorated.

[0021] The ascorbic acid compounds are for improving the deposition property of the gold plating on the gold plating film deposited by the hydrazine compounds so as to facilitate the formation of the gold plating film, and the ascorbic acid compounds make it possible to form a gold plating film with a sufficient thickness (of 0.1 μm or thicker).

[0022] Examples of the ascorbic acid compounds include alkali metal salts such as ascorbic acid and sodium ascorbyl phosphate, alkali earth metal salts such as magnesium ascorbyl phosphate, esters such as ascorbic acid 2-glucoside, and the like. These ascorbic acid compounds may be used solely, or a combination of two or more thereof may be used.

[0023] Moreover, the concentration of the ascorbic acid compound (which may be ascorbic acid compounds) in the plating bath may be in a range of 1 g/L to 20 g/L, preferably. If the concentration of the ascorbic acid is less than 1 g/L, the plating rate would become insufficient, and if the concentration of the ascorbic acid is greater than 20 g/L, the plating rate would not be improved so significantly regardless of the concentration, while bath stability of the plating bath would be deteriorated.

[0024] The electroless gold plating bath of the present disclosure is configured as follows: The reducing agent includes a combination of the hydrazine compounds and the ascorbic acid compounds used at once, the hydrazine compounds being capable of facilitating the formation of the gold plating film on the nickel plating film and the palladium plating film, and the hydrazine compounds being capable of facilitating the formation of the gold plating film by improving the deposition property of the gold plating on the gold plating film deposited by the hydrazine compounds, thereby making it possible to form a uniform gold plating film (that is, uniform in outer appearance and excellent in the deposition property) with a sufficient thickness (of 0.1 μm or thicker) in one step process either in the ENIG process or ENEPIG process.

(Amine-Based Complexing Agent)

[0025] An amine-based complexing agent is for improving the adhesion of the gold plating film to the electroless nickel plating film, and the electroless gold plating bath of the present disclosure includes an ethyleneamine as the amine-based complexing agent.

[0026] Examples of the ethyleneamine include ethylenediamine, diethylenetriamine, triethylenetetramine, tetraethylenepentamine, pentaethylenhexamine, and the like. These polyethyleneamines may be used solely, or a combination of two or more thereof may be used.

[0027] Moreover, the concentration of the amine-based complexing agent in the plating bath may be in a range of 0.5 g/L to 10 g/L, preferably.

(Miscellaneous)

[0028] The plating bath of the present disclosure may be configured such that the electroless gold plating bath further includes a known additive(s) of various kinds, if necessary. Examples of the additive include an anti-corrosion agent, an electric conducting salt, and the like.

[0029] More specifically, the anti-corrosion agent is an agent for preventing the corrosion on the surfaces of the nickel plating film and palladium plating film. In the electroless gold plating bath of the present disclosure, the anti-corrosion agent is not particularly limited, but for example, the anti-corrosion agent may be 1,2,3-benzotriazole, 1,2,4-triazole, 3-amino-1,2,4-triazole, 3-mercapto-1,2,4-triazole, 3-carboxamido-1,2,4-triazole, 3-aminopyrrolidine, 3-aminopyrazole, or the like.

[0030] Moreover, the concentration of the anti-corrosion agent in the plating bath may be in a range of 0.1 g/L to 2 g/L, preferably.

[0031] Moreover, examples of the electric conducting salt include sodium succinate, trisodium citrate, sodium malate, disodium malonate, sodium oxalate, disodium glutarate, sodium tartrate, and the like.

[0032] Moreover, the concentration of the electric conducting salt in the plating bath may be in a range of 5 g/L to 100 g/L, preferably.

[0033] Moreover, the formation of the gold plating film with the sufficient thickness (of 0.1 μm or thicker) on the surface of the nickel plating film and/or the palladium plating film would result in deterioration of the adhesion of the gold plating film to the electroless nickel plating film and/or corrosion on the surface of the electroless nickel plating film and/or the electroless palladium plating film. Therefore, in order to suppress the deterioration of the adhesion of the gold plating film to the electroless nickel plating film and to suppress the corrosion on the surface of the electroless nickel plating film and/or the electroless palladium plating film, it is preferable that a mass ratio between the anti-corrosion agent and the amine-based complexing agent be anti-corrosion agent: amine-based complexing agent = 1: 0.5 to 1: 10.

(pH)

[0034] It is preferable that pH of the electroless gold plating bath of the present disclosure is in a range of 6 to 9. If the pH is less than 6, the plating rate would be insufficient, and if pH is greater than 9, the plating bath would be unstable.

[0035] The pH of the plating bath can be adjusted by a pH adjuster such as sodium hydroxide, potassium hydroxide, ammonia water, tetramethyl ammonium hydroxide, sulfuric acid, hydrochloric acid, boric acid, phosphoric acid, monocarboxylic acid, or dicarboxylic acid.

(Temperature of Plating Bath)

[0036] The temperature of the plating bath is not particularly limited, but may be in a range of 50°C to 80°C, preferably. If the temperature of the plating bath is less than 50°C, a deposition rate would be excessively slow, which would result in a long plating time, undesirably. If the temperature of the plating bath is higher than 80°C, the deposition rate would be excessively fast, which would produce coarse films, which would cause warping of a substrate due to thermal shrinkage of the films after the plating. Thus, such a high temperature of the plating bath is not preferable.

(Plating Object)

[0037] The electroless gold plating bath of the present disclosure is applicable to any kinds of plating objects, and is applicable to plating objects which have been treated with known electroless gold plating processes (for example, wiring circuits, terminal portions, and the like of electronic parts such as printed wiring boards, ceramics substrates, semiconductor substrates, IC packages, and the like).

<Electroless Gold Plating Process>

[0038] The electroless gold plating bath according to the present disclosure is, for example, electroless gold plating process in the ENIG process and the ENEPIG process. For example, an electroless gold plating film can be formed on a palladium plating film by implementing the electroless gold plating bath according to the present disclosure in such a way that a surface of a palladium plating film is subjected to the electroless gold plating process by immersing the palladium plating film in the electroless gold plating film. The temperature of the electroless gold plating process is adjusted to the bath temperature of the electroless gold plating bath described above.

[0039] Moreover, a process time of the electroless gold plating process is not particularly limited and may be adjusted as appropriate to attain a desired film thickness. More specifically, the electroless gold plating process may be, for example in a range of 30 sec to 15 hours, approximately.

[EXAMPLES]

[0040] The following describes the present disclosure more specifically based on Examples and Comparative Examples. However, the present invention is not limited to the following Examples.

[0041] First, to confirm that the electroless gold plating bath according to the present disclosure works usefully, the deposition property of gold plating films formed by plating process using the electroless gold plating bath according to the present disclosure was evaluated.

<Evaluation of Deposition Property of Gold Plating on Electroless Nickel-Phosphorus Plating film (with a phosphorus concentration of 6 to 8% in the film)>

(Preparation of Plating Bath)

[0042] An electroless gold plating bath of Example 1 was prepared by mixing and stirring a gold sulfite (sodium gold sulfite), sodium succinate as the electric conducting salt, sodium thiosulfate and disodium sulfite as the complexing agent, 1,2,3-benzotriazole as the anti-corrosion agent, ethylenediamine as the amine-based complexing agent, and ascorbic acid and adipic dihydrazide as the reducing agent with concentrations listed in Table 1. The plating bath was set to a temperature (i.e., temperature of the plating processing) of 70°C, and the pH was set to 7.5.

[Table 1]

			Composition of Plating Bath	
			Example	
			1	
	Gold Sulfite	Sodium Gold Sulfite (as Au)	g/L	1
	Electric Conducting Salt	Sodium Succinate	g/L	30
	Complexing Agent	Sodium Thiosulfate	g/L	1
		Disodium Sulfite	g/L	30
	Anti-Corrosion Agent	1,2,3-Benzotriazole	g/L	1
	Amine-based Complexing Agent	Ethylenediamine	g/L	1
	Reducing Agent (Ascorbic Acid Compounds)	Ascorbic Acid	g/L	5
	Reducing Agent (Hydrazine Compounds)	Adipic Dihydrazide	g/L	5
Process Temperature			(°C)	70
pH				7.5

(Pretreatment)

[0043] A TEG wafer with electrodes made from an aluminum-copper alloy, which is an aluminum alloy, was provided and the electrodes were treated with the following pretreatment steps 1 to 5 in this order.

[0044] Step 1: A substrate (TEG wafer) was treated with a degreasing cleaning treatment (50°C, 300 sec) with a degreasing cleaner (EPITHAS MCL-16 (product name) available from C. Uyemura & Co., Ltd.).

[0045] Step 2: Next, the substrate was treated with a pickling treatment (21°C, 30 sec) with a nitric acid solution of 30 wt%, thereby forming an oxide film on the surface of the substrate.

[0046] Step 3: Next, the substrate was treated with a primary zincate treatment (21°C, 20 sec) with a zincate treatment bath (with EPITHAS MCT-51 (product name) available from C. Uyemura & Co., Ltd.).

[0047] Step 4: The substrate was treated with a pickling treatment (21°C, 60 sec) with the nitric acid solution of 30 wt%, so as to peel off the zincate film and forming an oxide film on the surface of the substrate.

[0048] Step 5: Next, the substrate was treated with a secondary zincate treatment (21°C, 40 sec) with a zincate treatment bath (with EPITHAS MCT-51 (product name) available from C. Uyemura & Co., Ltd.).

(Plating Processing)

[0049] Next, the substrate thus prepared was treated with an electroless plating process (80°C, 15 min) with a nickel-phosphorus plating bath (with EPITHAS NPR-18 (product name) available from C. Uyemura & Co., Ltd.), thereby forming a nickel plating film (a nickel plating film with a phosphorus concentration of 6% to 8% in the film and a thickness of 3 μm) on the substrate.

[0050] Next, the substrate with the nickel plating film thereon was immersed for 15 min in the plating bath prepared as above, thereby forming an electroless gold plating film on the plating object.

(Plating Deposition Property)

[0051] The substrate thus treated with the electroless gold plating process was visually observed in terms of tonal change of the outer appearance of the substrate due to the gold deposition, so as to evaluate the deposition property of the gold plating film formed by the plating process. The evaluation found that the surface color of the substrate had been changed to yellow, confirming gold deposition.

<Evaluation of Deposition Property of Gold Plating on Electroless Nickel-Phosphorus Plating film (with a phosphorus concentration of 2 to 4% in the film)>

[0052] A TEG wafer with electrodes made from an aluminum-copper alloy, which is an aluminum alloy, was provided and the electrodes were treated with the aforementioned pretreatment steps 1 to 5 in this order.

[0053] Next, the substrate thus prepared was treated with an electroless plating process (80°C, 15 min) with a nickel-phosphorus plating bath (with EPITHAS NLL-1 (product name) available from C. Uyemura & Co., Ltd.), thereby forming a nickel plating film (a nickel plating film with a phosphorus concentration of 2% to 4% in the film and a thickness of 3 μm) on the substrate.

[0054] Next, the substrate with the nickel plating film thereon was immersed for 15 min in the plating bath prepared as above, thereby forming an electroless gold plating film on the plating object.

[0055] The substrate was evaluated in terms of the deposition property of the plating, finding a surface color change of the substrate to yellow and thereby confirming gold deposition.

<Evaluation of Deposition Property of Gold Plating on Electroless Nickel-Bismuth Alloy Plating Film>

[0056] A TEG wafer with electrodes made from an aluminum-copper alloy, which is an aluminum alloy, was provided and the electrodes were treated with the aforementioned pretreatment steps 1 to 5 in this order.

[0057] Next, the substrate thus prepared was treated with an electroless plating process (80°C, 15 min) with a nickel-bismuth plating bath (with EPITHAS KSB-18 (product name) available from C. Uyemura & Co., Ltd.), thereby forming a nickel plating film (with a thickness of 3 μm) on the substrate.

[0058] Next, the substrate with the nickel plating film thereon was immersed for 15 min in the plating bath prepared as above, thereby forming an electroless gold plating film on the plating object.

[0059] The substrate was evaluated in terms of the deposition property of the plating, finding a surface color change of the substrate to yellow and thereby confirming gold deposition.

<Evaluation of Deposition Property of Gold Plating on Electroless Palladium Plating Film>

[0060] A TEG wafer with electrodes made from an aluminum-copper alloy, which is an aluminum alloy, was provided and the electrodes were treated with the aforementioned pretreatment steps 1 to 5 in this order.

[0061] Next, the substrate thus prepared was treated with an electroless plating process (80°C, 15 min) with a nickel-phosphorus plating bath (with EPITHAS NPR-18 (product name) available from C. Uyemura & Co., Ltd.), thereby forming a nickel plating film (with a thickness of 3 μm) on the substrate.

[0062] Next, the substrate was treated with an electroless plating process (56°C, 15 min) with a palladium plating bath (with EPITHAS TFP-25 (product name) available from C. Uyemura & Co., Ltd.), thereby forming a palladium plating film (with a thickness of 0.3 μm) on the nickel plating film.

[0063] Next, the substrate with the palladium plating film was immersed for 15 min in the plating bath prepared as above, thereby forming an electroless gold plating film on the plating object.

[0064] The plating object was evaluated in terms of the deposition property of the plating, finding a surface color change of the substrate to yellow and thereby confirming gold deposition.

<Evaluation of Deposition Property of Gold Plating on Electroless Palladium-Phosphorus Plating Film>

[0065] A TEG wafer with electrodes made from an aluminum-copper alloy, which is an aluminum alloy, was provided and the electrodes were treated with the aforementioned pretreatment steps 1 to 5 in this order.

[0066] Next, the substrate thus prepared was treated with an electroless plating process (80°C, 15 min) with a nickel-phosphorus plating bath (with EPITHAS NPR-18 (product name) available from C. Uyemura & Co., Ltd.), thereby forming a nickel plating film (with a thickness of 3 μm) on the substrate.

[0067] Next, the substrate thus prepared was treated with an electroless plating process (50°C, 15 min) with a palladium-phosphorus plating bath (with EPITHAS TFP-30 (product name) available from C. Uyemura & Co., Ltd.), thereby forming a palladium plating film (with a thickness of 0.15 μm) on the nickel plating film.

[0068] Next, the substrate with the palladium plating film was immersed for 15 min in the plating bath prepared as above, thereby forming an electroless gold plating film on the plating object.

[0069] The substrate was evaluated in terms of the deposition property of the plating, finding a surface color change of the substrate to yellow and thereby confirming gold deposition.

<Evaluation of Deposition Property of Gold Plating on Electroless Platinum Plating Film>

[0070] A TEG wafer with electrodes made from an aluminum-copper alloy, which is an aluminum alloy, was provided and the electrodes were treated with the aforementioned pretreatment steps 1 to 5 in this order.

[0071] Next, the substrate thus prepared was treated with an electroless plating process (80°C, 15 min) with a nickel-phosphorus plating bath (with EPITHAS NPR-18 (product name) available from C. Uyemura & Co., Ltd.), thereby forming a nickel plating film (with a thickness of 3 μm) on the substrate.

[0072] Next, the substrate thus prepared was treated with an electroless plating process (78°C, 7 min) with a platinum plating bath (with EPITHAS TAE-30 (product name) available from C. Uyemura & Co., Ltd.), thereby forming a platinum plating film (with a thickness of 0.2 μm) on the nickel plating film.

[0073] Next, the substrate with the platinum plating film thereon was immersed for 15 min in the plating bath prepared as above, thereby forming an electroless gold plating film on the plating object.

[0074] The substrate was evaluated in terms of the deposition property of the plating, finding a surface color change of the substrate to yellow and thereby confirming gold deposition.

<Evaluation of Deposition Property of Gold Plating on Electroless Cobalt-Tungsten-Phosphorus Plating Film>

[0075] A TEG wafer with electrodes made from an aluminum-copper alloy, which is an aluminum alloy, was provided and the electrodes were treated with the aforementioned pretreatment steps 1 to 5 in this order.

[0076] Next, the substrate thus prepared was treated with an electroless plating process (75°C, 60 min) with a cobalt-tungsten-phosphorus plating bath (with EPITHAS HWP-5 (product name) available from C. Uyemura & Co., Ltd.), thereby forming a cobalt alloy plating film (with a thickness of 0.3 μm) on the substrate.

[0077] Next, the substrate with the cobalt alloy plating film thereon was immersed for 15 min in the plating bath prepared as above, thereby forming an electroless gold plating film on the plating object.

[0078] The substrate was evaluated in terms of the deposition property of the plating, finding a surface color change of the substrate to yellow and thereby confirming gold deposition.

<Evaluation of Deposition Property of Gold Plating on Electroless Cobalt-Tungsten-Boron Plating Film>

[0079] A TEG wafer with electrodes made from an aluminum-copper alloy, which is an aluminum alloy, was provided and the electrodes were treated with the aforementioned pretreatment steps 1 to 5 in this order.

[0080] Next, the substrate thus prepared was treated with an electroless plating process (75°C, 60 min) with a cobalt-tungsten-boron plating bath (with EPITHAS HWB-31 (product name) available from C. Uyemura & Co., Ltd.), thereby forming a cobalt alloy plating film (with a thickness of 0.5 μm) on the substrate.

[0081] Next, the substrate with the cobalt alloy plating film thereon was immersed for 15 min in the plating bath prepared as above, thereby forming an electroless gold plating film on the plating object.

[0082] The substrate was evaluated in terms of the deposition property of the plating, finding a surface color change of the substrate to yellow and thereby confirming gold deposition.

[0083] As described above, it was confirmed that gold was successfully deposited by the use of the electroless gold plating bath according to the present disclosure in any of the cases where the base plating film was the electroless nickel-phosphorus plating film, the electroless nickel-bismuth plating film, the electroless palladium plating film, the electroless palladium-phosphorus plating film, the electroless platinum plating film, or the electroless cobalt alloy plating film, thereby confirming that the electroless gold plating bath according to the present disclosure could work usefully.

<Formation of Electroless Gold Plating Film in the ENIG Process and ENEPIG Process>

[0084] Next, properties of gold plating films formed by the plating process with the electroless gold plating bath in the ENIG Process and ENEPIG process were evaluated.

(Examples 1 to 48 and Comparative Examples 1 to 9)

(Preparation of Plating Bath)

[0085] Electroless gold plating baths of Examples 1 to 48 and Comparative Examples 1 to 9 were prepared by mixing and stirring a gold sulfite (sodium gold sulfite), sodium succinate as the electric conducting salt, sodium thiosulfate and disodium sulfite as the complexing agent, 1,2,3-benzotriazole as the anti-corrosion agent, an amine-based complexing agent, and ascorbic acid compounds and hydrazine compounds as the reducing agent with concentrations listed in Tables 2 to 6. The plating bath was set to a temperature (i.e., temperature of the plating processing) in a range of 50°C to 80°C, and the pH was set in a range of 6 to 9.

(Formation of Electroless Gold Plating Film in the ENIG Process)

[0086] A TEG wafer with electrodes made from an aluminum-copper alloy, which is an aluminum alloy, was provided and the electrodes were treated with the aforementioned pretreatment steps 1 to 5 in this order.

[0087] Next, the substrate thus prepared was treated with an electroless plating process (80°C, 15 min) with a nickel-phosphorus plating bath (with EPITHAS NPR-18 (product name) available from C. Uyemura & Co., Ltd.), thereby forming a nickel plating film (with a thickness of 3 μm) on the substrate.

[0088] Next, the substrate with the nickel plating film thereon was immersed for 15 min in the plating bath of one of Examples 1 to 48 and Comparative Examples 1 to 9, thereby forming an electroless gold plating film on the nickel plating film.

(Formation of Electroless Gold Plating Film in the ENEPIG process)

[0089] A TEG wafer with electrodes made from an aluminum-copper alloy, which is an aluminum alloy, was provided and the electrodes were treated with the aforementioned pretreatment steps 1 to 5 in this order.

[0090] Next, the substrate thus prepared was treated with an electroless plating process (80°C, 15 min) with a nickel-phosphorus plating bath (with EPITHAS NPR-18 (product name) available from C. Uyemura & Co., Ltd.), thereby forming a nickel plating film (with a thickness of 3 μm) on the substrate.

[0091] Next, the substrate was treated with an electroless plating process (56°C, 15 min) with a palladium plating bath (with EPITHAS TFP-25 (product name) available from C. Uyemura & Co., Ltd.), thereby forming a palladium plating film (with a thickness of 0.3 μm) on the nickel plating film.

[0092] Next, the substrate with the nickel plating film thereon was immersed for 15 min in the plating bath of one of Examples 1 to 48 and Comparative Examples 1 to 9, thereby forming an electroless gold plating film on the palladium plating film.

(Outer Appearance Unevenness)

[0093] The surfaces of the electroless gold plating film were visually observed to evaluate in such a way that films with uniform gold color outer appearance were evaluated as good, and films with color changes to red instead of gold were evaluated as poor. The results of the evaluation are presented in Tables 2 to 6.

(Film Peeling-Off of the Electroless Gold Plating Film)

[0094] A sample of the electroless gold plating film with a size of $2.5 \text{ cm} \times 2.5 \text{ cm}$ was prepared. An adhesive cellophane tape with a width of approximately 2 cm was adhered to a surface of the electroless gold plating film and manually peeled off from the surface. If the electroless gold plating film was not peeled off together with the tape, the electroless gold plating film was evaluated as good, and if peeled off, the electroless gold plating film was evaluated as poor. The results of the evaluation are presented in Tables 2 to 6.

(Deposition Property)

[0095] The surfaces of the electroless gold plating film were observed with a scanning electron microscope (SEM, available from JEOL Ltd.) to evaluate in such a way that films with uniform gold plating deposition were evaluated as good, and films with non-uniform gold plating deposition, in which gold deposition was partially unsuccessful, were evaluated as poor. The results of the evaluation are presented in Tables 2 to 6.

(Corrosivity)

[0096] By using COPKIARIP AU-1 (available from C. Uyemura & Co., Ltd.), the electroless gold plating film was peeled off, and a base film of the electroless gold plating film (the surface of the electroless nickel plating film in the case of the ENIG process and the electroless nickel plating film under the electroless palladium plating film in the case of ENEPIG process) was observed by a scanning electron microscope, and a cross-section thereof was observed with a focused ion beam (FIB) device (available from Hitachi High-Tech Corporation), evaluating as poor if the electroless nickel plating film has corrosion on the surface or the cross-section thereof (that is, if the electroless nickel plating film has a hole on the surface or a hole or staining on the cross-section) and evaluating as good if the electroless nickel plating film had no such corrosion. The results of the evaluation are presented in Tables 2 to 6.

(Measurement of Thickness of Electroless Gold Plating Film)

[0097] Next, the thicknesses of the electroless gold plating films were measured by using an X-ray fluorescence thickness meter available from FISCHER INSTRUMENTS K.K. The results of the evaluation are presented in Tables 2 to 6.

[Table 2]

Compositions of Plating Baths														
Examples														
	1	2	3	4	5	6	7	8	9	10	11	12		
Gold Sulfite	1	1	1	1	1	1	1	1	1	1	1	1		
Electric Conducting Salt	30	30	30	30	30	30	30	30	30	30	30	30		
Complexing Agent	1	1	1	1	1	1	1	1	1	1	1	1		
	30	30	30	30	30	30	30	30	30	30	30	30		
Anti-Corrosion Agent	1	1	1	1	1	1	1	1	1	1	1	1		
Amine-based Complexing	1	1	1	1	1	1	1	1	1	1	1	1		
Reducing Agent (Ascorbic Acid Compounds)	5	5	5				20	1	5	5	5	5		
				5										
					5									
					</									

(continued)

	Compositions of Plating Baths											
	Examples											
	1	2	3	4	5	6	7	8	9	10	11	12
Process Temperature (°C)	70											
pH	7.5											
ENIG Process	Uniform Outer Appearance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Peeling-Off of Electroless Gold Plating Film	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Deposition Property	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Corrosion	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
ENEPIG Process	Film Thickness of Electroless Gold Plating Film (μm)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Uniform Outer Appearance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Peeling-Off of Electroless Gold Plating Film	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Deposition Property	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Corrosion	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Film Thickness of Electroless Gold Plating Film (μm)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

[Table 3]

		Compositions of Plating Baths											
		Examples											
		13	14	15	16	17	18	19	20	21	22	23	24
Gold Sulfite	Sodium Gold Sulfite (as Au)	1	1	1	1	1	1	1	1	1	1	1	1
Electric Conducting Salt	Sodium Succinate	30	30	30	30	30	30	30	30	30	30	30	30
Complexing Agent	Sodium Thiosulfate	1	1	1	1	1	1	1	1	1	1	1	1
	Disodium Sulfite	30	30	30	30	30	30	30	30	30	30	30	30
Anti-Corrosion Agent	1,2,3 -Benzotriazole	1	1	1	1	1	1	1	1	1	1	1	1
Amine-based Complexing Agent	Ethylenediamine	1	1	1	1	1	1	1	1	1	1	1	1
Reducing Agent (Ascorbic Acid Compounds)	Ascorbic Acid	5	5	5	5	5	5	5	5	5	5	5	5

(continued)

		Compositions of Plating Baths											
		Examples											
		13	14	15	16	17	18	19	20	21	22	23	24
Reducing Agent (Hydrazine Compounds)	Hydrazine Carbonate	g/L											
	Hydrazine Monohydrate	g/L	5										
	Sebacic Dihydrazide	g/L		5									
	Dodecanediohydrazide	g/L			5								
	Isophthalic Dihydrazide	g/L				5							
	Salicylic Hydrazide	g/L					5						
	3-Hydro-2-Naphthoic Hydrazide,	g/L						5					
	Benzophenone Hydrazone	g/L							5				
	Phenylhydrazine	g/L								5			
	Benzylhydrazine Monohydrochloride	g/L									5		
Gold: Sodium Thiosulfate	Methylhydrazine Sulfate	g/L										5	
	Isopropylhydrazine Hydrochloride	g/L											5
Anti-Corrosion Agent: Amine-based Complexing Agent		1:1											
Process Temperature (°C)		70											
pH		7.5											

(continued)

		Compositions of Plating Baths											
		Examples											
		13	14	15	16	17	18	19	20	21	22	23	24
ENIG Process	Uniform Outer Appearance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Peeling-Off of Electroless Gold Plating Film	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Deposition Property	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Corrosion	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Film Thickness of Electroless Gold Plating Film (μm)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
ENEPIG Process	Uniform Outer Appearance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Peeling-Off of Electroless Gold Plating Film	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Deposition Property	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Corrosion	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Film Thickness of Electroless Gold Plating Film (μm)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

[Table 4]

		Compositions of Plating Baths												
		Examples												
		25	26	27	28	29	30	31	32	33	34	35	36	
Gold Sulfite	Sodium Gold Sulfite (as Au)	1	1	1	1	1	1	1	1	1	0.5	2		
Electric Conducting Salt	Sodium Succinate	30	30	30	30	30	30	30	30	30	30	30		
Complexing Agent	Sodium Thiosulfate	1	1	1	1	1	1	1	1	0.5	10	1	1	
	Disodium Sulfite	30	30	30	30	30	30	30	30	30	30	30	30	
Anti-Corrosion Agent	1,2,3-Benzotriazole	1	1	1	1	1	1	1	1	1	1	1	1	
Amine-based Complexing	Ethylenediamine	1	1	1	1	1	1	1	1	1	1	1	1	
Reducing Agent (Ascorbic Acid Compounds)	Ascorbic Acid	5	5	5	5	5	5	5	5	5	5	5	5	

(continued)

		Compositions of Plating Baths											
		Examples											
		25	26	27	28	29	30	31	32	33	34	35	36
Reducing Agent (Hydrazine Compounds)	Adipic Dihydrazide	g/L											
	1,1-Dimethylhydrazine	g/L	5							5	5	5	5
	2-Hydrazinobenzothiazole	g/L	5										
	Acetohydrazide	g/L		5									
	2-Hydroxyethylhydrazine	g/L			5								
	Ethoxycarbonylhydrazine	g/L				5							
	Methoxycarbonylhydrazine	g/L					5						
	Phenylhydrazine-4-Sulfonic acid	g/L						5					
Benzohydrazide		g/L							5				
Gold: Sodium Thiosulfate			1:1	1:1	1:1	1:1	1:1	1:1	1:1	2:1	1:10	1:2	2:1
Anti-Corrosion Agent: Amine-based Complexing Agent			1:01										
Process Temperature (°C)			70										
pH			7.5										

(continued)

		Compositions of Plating Baths											
		Examples											
		25	26	27	28	29	30	31	32	33	34	35	36
ENIG Process	Uniform Outer Appearance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Peeling-Off of Electroless Gold Plating Film	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Deposition Property	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Corrosion	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Film Thickness of Electroless Gold Plating Film (μm)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
ENEPIG Process	Uniform Outer Appearance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Peeling-Off of Electroless Gold Plating Film	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Deposition Property	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Corrosion	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Film Thickness of Electroless Gold Plating Film (μm)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

[Table 5]

		Compositions of Plating Baths													
		Examples													
		37	38	39	40	41	42	43	44	45	46	47	48		
Gold Sulfite	Sodium Gold Sulfite (as Au)	1	1	1	1	1	1	1	1	1	1	1	1		
Electric Conducting Salt	Sodium Succinate	30	30	30	30	30	30	30	30	30	30	30	30		
Complexing Agent	Sodium Thiosulfate	1	1	1	1	1	1	1	1	1	1	1	1		
	Disodium Sulfite	30	30	30	30	30	30	30	30	30	30	30	30		
Anti-Corrosion Agent	1,2,3 - Benzotriazole	1	1	1	1	1	1	0.1	2	1	1	1	1		
Amine-based Complexing Agent	Ethylenediamine					0.5	10	1	1	1	1	1	1		
	Diethylenetriamine	1													
	Triethylenetetramine		1												
	Tetraethylenepentamine			1											
	Pentaethylenhexamine				1										
Reducing Agent (Ascorbic Acid Compounds)	Ascorbic Acid	5	5	5	5	5	5	5	5	5	5	5	5		
Reducing Agent (Hydrazine Compounds)	Adipic Dihydrazide	5	5	5	5	5	5	5	5	5	5	5	5		
Gold: Sodium Thiosulfate		1:1													
Anti-Corrosion Agent: Amine-based Complexing Agent		1:1	1:1	1:1	1:1	2:1	1:10	1:10	2:1	1:1	1:1	1:1	1:1		
Process Temperature (°C)		70	70	70	70	70	70	70	70	70	70	50	80		
pH		7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	6	9	7.5	7.5		

(continued)

		Compositions of Plating Baths											
		Examples											
		37	38	39	40	41	42	43	44	45	46	47	48
ENIG Process	Uniform Outer Appearance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Peeling-Off of Electroless Gold Plating	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Deposition Property	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Corrosion	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Film Thickness of Electroless Gold Plating Film (μm)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
ENEPIG Process	Uniform Outer Appearance	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Peeling-Off of Electroless Gold Plating	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Deposition Property	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	No Corrosion	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
	Film Thickness of Electroless Gold Plating Film (μm)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

[Table 6]

		Compositions of Plating Baths									
		Comparative Examples									
		1	2	3	4	5	6	7	8	9	
Gold Sulfite	Sodium Gold Sulfite (as Au)	g/L									
Electric Conducting Salt	Sodium Succinate	g/L									
Complexing Agent	Sodium Thiosulfate	g/L									
	Disodium Sulfite	g/L									
Anti-Corrosion Agent	1,2,3 -Benzotriazole	g/L									
Amine-based Complexing Agent	Ethylenediamine	g/L									
Reducing Agent (Ascorbic Acid Compounds)	Ascorbic Acid	g/L									
Reducing Agent (Hydrazine Compounds)	Adipic Dihydrazide	g/L									
Gold: Sodium Thiosulfate											
Anti-Corrosion Agent: Amine-based Complexing Agent											
Process Temperature (°C)											
pH											
ENIG Process	Uniform Outer Appearance										
	No Peeling-Off of Electroless Gold Plating Film										
	Deposition Property										
	No Corrosion										
	Film Thickness of Electroless Gold Plating Film (μm)										

(continued)

Compositions of Plating Baths									
Comparative Examples									
1	2	3	4	5	6	7	8	9	
ENEPIG Process	Uniform Outer Appearance	Poor	Good	Poor	Good	Good	Good	Good	Good
	No Peeling-Off of Electroless Gold Plating Film	Good	Good	Good	Good	Good	Good	Good	Good
	Deposition Property	Poor	Poor	Good	Good	Good	Good	Good	Good
	No Corrosion	Good	Good	Poor	Good	Good	Poor	Poor	Good
	Film Thickness of Electroless Gold Plating Film (μm)	0.1	0.03	0.03	0.1	0.1	0.1	0.1	0.1

[0098] As demonstrated in Tables 2 to 5, the electroless gold plating baths of Examples 1 to 48, including a gold sulfite, a thiosulfate, ascorbic acid compounds, and hydrazine compounds, wherein a combination of the hydrazine compounds and the ascorbic acid serve as a reducing agent, make it possible to form a uniform gold plating film (that is, uniform in outer appearance and excellent in the deposition property) with a sufficient thickness (of 0.1 μm or thicker) by a single-step process either in the ENIG process or ENEPIG process, because the hydrazine compounds capable of facilitating the formation of the gold plating film on the nickel plating film or the palladium plating film and the ascorbic acid compounds capable of facilitating the formation of the gold plating film by improving the deposition property of the gold plating on the gold plating film deposited by the hydrazine are used at once.

[0099] On the other hand, the Comparative Example 1 without hydrazine compounds was poor in the outer appearance and deposition property, and the gold plating film thereof was not uniform, as understood from Table 6.

[0100] Moreover, the Comparative Example 2 without ascorbic acid compounds was poor in the deposition property, and the gold plating film thereof was not uniform.

[0101] Moreover, the Comparative Example 3 without a sodium thiosulfate was unstable in gold solubility in the electroless gold plating bath and poor in the outer appearance and deposition property, and the gold plating film thereof was not uniform.

[0102] Moreover, the Comparative Example 4, in which the mass ratio of the gold in the gold sulfite to the sodium thiosulfate was 1: 15 out of the range of gold: sodium thiosulfate = 1: 0.5 to 1: 10, was poor in the adhesion of the gold plating film to the electroless nickel plating film and corrosion occurred on the surface of the electroless nickel plating film.

[0103] Moreover, the Comparative Example 5, in which the mass ratio of the gold in the gold sulfite to the sodium thiosulfate was 5: 1 out of the range of gold: sodium thiosulfate = 1: 0.5 to 1: 10, was poor in the adhesion of the gold plating film to the electroless nickel plating film.

[0104] Moreover, the Comparative Example 6 without ethylene diamine was poor in the adhesion of the gold plating film to the electroless nickel plating film.

[0105] Moreover, the Comparative Example 7, in which the mass ratio of the anti-corrosion agent to amine-based complexing agent was 1: 15 out of the range of anti-corrosion agent: amine-based complexing agent = 1: 0.5 to 1: 10, was poor in the adhesion of the gold plating film to the electroless nickel plating film and corrosion occurred on the surface of the electroless nickel plating film.

[0106] Moreover, the Comparative Example 8 without an anti-corrosion agent was poor in the adhesion of the gold plating film to the electroless nickel plating film, because local corrosions increased on the electroless nickel plating film, causing gaps between the corroded portion of the electroless nickel plating film and the electroless gold plating film.

[0107] Moreover, the Comparative Example 9, in which the mass ratio of the anti-corrosion agent to the amine-based complexing agent was 3: 1 out of the range of anti-corrosion agent: amine-based complexing agent = 1: 0.5 to 1: 10, was poor in the adhesion of the gold plating film to the electroless nickel plating film.

INDUSTRIAL APPLICABILITY

[0108] The electroless gold plating bath according to the present disclosure is suitably applicable especially to formation of an electroless gold plating film in the ENIG process and the ENEPIG process.

Claims

1. An electroless gold plating bath, comprising a gold sulfite, a thiosulfate, ascorbic acid compounds, and hydrazine compounds,
the hydrazine compounds being at least one selected from the group consisting of adipic dihydrazide, propionic hydrazide, hydrazine sulfate, hydrazine monohydrochloride, hydrazine dihydrochloride, hydrazine carbonate, hydrazine monohydrate, sebacic dihydrazide, dodecanediohydrazide, isophthalic dihydrazide, salicylic hydrazide, 3-hydro-2-naphthoic hydrazide, benzophenone hydrazone, phenylhydrazine, benzylhydrazine monohydrochloride, methylhydrazine sulfate, isopropylhydrazine hydrochloride, 1,1-dimethylhydrazine, 2-hydrazinobenzothiazole, acetohydrazide, 2-hydroxyethylhydrazine, ethoxycarbonylhydrazine, methoxycarbonylhydrazine, phenylhydrazine-4-sulfonic acid, and benzohydrazide.
2. The electroless gold plating bath of claim 1, wherein
the ascorbic acid compounds are at least one selected from the group consisting of ascorbic acid, sodium ascorbyl phosphate, magnesium ascorbyl phosphate, and ascorbic acid 2-glucoside.
3. The electroless gold plating bath of claim 1 or 2, wherein
a concentration of the hydrazine compounds is in a range of 0.5 g/L to 15 g/L and a concentration of the ascorbic

acid compounds is in a range of 1 g/L to 20 g/L.

4. The electroless gold plating bath of any one of claims 1 to 3, wherein
a mass ratio of gold in the gold sulfite to the thiosulfate is in a range of gold: thiosulfate = 1: 0.5 to 1: 10.

5. The electroless gold plating bath of any one of claims 1 to 4, further comprising:

an anti-corrosion agent and an amine-based complexing agent, wherein
a mass ratio of the anti-corrosion agent to the amine-based complexing agent is in a range of anti-corrosion
agent: amine-based complexing agent = 1: 0.5 to 1: 10.



EUROPEAN SEARCH REPORT

Application Number

EP 22 19 7168

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EPO FORM 1503 03.82 (P04C01)

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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