

DESCRIPTION

TIN AND TIN ALLOY ELECTROPLATING SOLUTIONS

Technical Field

[0001] The present invention relates to a tin electroplating solution and a tin alloy electroplating solution.

Background Art

[0002] In the past, tin electroplating and tin alloy electroplating, tin-zinc alloy plating in particular, had little reliability after soldering and was not practical because the solder wettability was poor. Moreover, even during the plating process, the cathode current efficiency was poor, the plating rate was slow, and the particles of the plated film obtained were coarse, thus also posing problems with appearance such as lack of luster.

DISCLOSURE OF THE INVENTION

Problems that the Invention is to Solve

[0003] Based on these circumstances, a first object of the present invention is to provide tin electroplating and tin alloy electroplating with satisfactory solder wettability, and to heighten the reliability after soldering. In addition, the plating rate and the appearance after plating, which were problems in the past, are to be improved.

Means for Solving the Problems

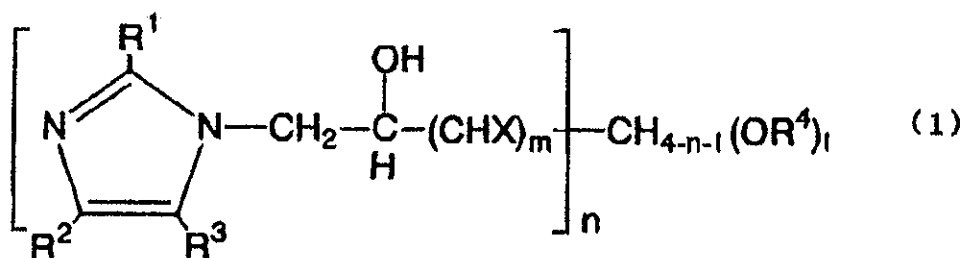
[0004] As a result of seriously studying the aforementioned problems, the inventors discovered that the aforementioned problems could be resolved by adding a compound having both an imidazole group and a hydroxyl group in one molecule to a conventional tin or tin alloy electroplating solution.

[0005] Specifically, the present invention is:

[1] Tin and tin alloy electroplating solutions, characterized by containing one or more compounds having an imidazole group and a hydroxyl group in one molecule.

[0006] [2] The tin and tin alloy electroplating solutions according to aforementioned [1] characterized in that the aforementioned compound having an imidazole group and a hydroxyl group in one molecule is an imidazole alcohol compound expressed by the following general formula (1),

[Chemical Formula 1]

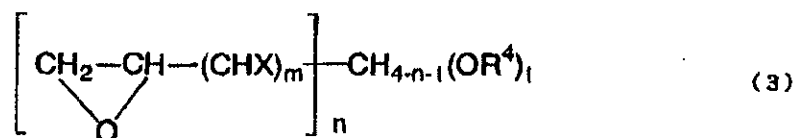


wherein in the general formula (1), R^1 , R^2 , R^3 each independently represent a hydrogen atom, a vinyl group or an alkyl group having 1 to 20 carbon atoms and R^2 and R^3 may be joined together to form an aromatic ring; R^4 represents a hydrogen atom, a vinyl group, an alkyl group having 1 to 20 carbon atoms, a phenyl group, or -

$(\text{CH}_2\text{CH}(\text{R}^5)\text{O})_k\text{H}$, with R^5 representing a hydrogen atom or an alkyl group having 1 to 20 carbon atoms and k representing an integer of from 1 to 20; X represents a hydrogen atom, an alkyl group having 1 to 6 carbon atoms, or a substituent that may contain N, O; m represents an integer of from 0 to 20; and n and l represent an integer of from 1 to 3.

[0007] [3] The tin and tin alloy electroplating solutions according to aforementioned [2] characterized in that the aforementioned compound represented by the general formula (1) is an imidazole alcohol compound obtained by reacting an imidazole compound represented by the general formula (2) below with an epoxy compound represented by the general formula (3) below,

[Chemical Formula 2]



wherein in the general formulae (2) and (3), R^1 , R^2 , R^3 represent each independently a hydrogen atom, a vinyl group or an alkyl group having 1 to 20 carbon atoms, and R^2 and R^3 may be joined together to form an aromatic ring; R^4 represents a hydrogen atom, a vinyl group, an alkyl group having 1 to 20 carbon atoms, a phenyl group, or $-(\text{CH}_2\text{CH}(\text{R}^5)\text{O})_k\text{H}$, with R^5 representing a hydrogen atom, or an alkyl group having 1 to 20 carbon atoms and k

representing an integer of from 1 to 20; X represents a hydrogen atom, an alkyl group having 1 to 6 carbon atoms, or a substituent that may contain N, O; m represents an integer of from 0 to 20; and n and l represent an integer of from 1 to 3.

Effects of the Invention

[0008] By using the tin electroplating solution and tin alloy electroplating solution of the present invention, it is possible to improve the solder wettability and external appearance of plated objects. Moreover, it is also possible to improve the plating rate by using the plating solution of the present invention.

Best Mode for Carrying Out the Invention

[0009] The tin and tin alloy electroplating solutions of the present invention are basically able to use conventional tin electroplating solutions and tin alloy electroplating solutions, and add thereto the aforementioned specified imidazole alcohol compound.

[0010] The tin electroplating solution and tin alloy electroplating solution are configured by a tin salt comprising the metal component of a plating film (or a tin salt and a metal salt comprising a metal forming an alloy with tin), a metal salt stabilizer (stabilizer that prevents tin from changing from bivalent to tetravalent), a brightening agent (smoothing agent, abnormal deposition preventative), conductive salts, and a pH adjuster, etc.

[0011] Regarding the tin salt comprising the metal component of a plating film and the metal salt of a metal forming an alloy with tin, concrete examples of tin salts include tin sulfate, tin chloride, tin sulfamate, and tin

methane sulfonate. Further, zinc, indium, bismuth, gold, silver, copper, and nickel can be cited as examples of the metal forming an alloy with tin; and these alloying metals may be used in the form of salts like those of the tin. The concentration of the tin salt in the tin electroplating solution is preferably from 1 to 60 g/L, calculated in terms of metal. In the case of the tin alloy electroplating solution, it is desirable that the solution contain, in addition to the tin salt at the above-mentioned preferable concentration, the salt of the metal forming an alloy with tin preferably in a concentration range of from 0.01 to 50 g/L, calculated in terms of metal.

[0012] The stabilizer for the metal salt or salts basically has the function of preventing the oxidation of tin, and ascorbic acid, erythorbate, polyhydric phenol, and hypophosphite can be used. The concentration of the stabilizer for the metal salt(s) in the electroplating solution is preferably from 1 to 50 g/L in the case of using hypophosphite and 0.05 to 10 g/L in the other cases.

[0013] Polyacrylamides and derivatives thereof, polyethylene glycol, and triethanolamine and derivatives thereof can be used as brightening agents. The brightening agent is preferably contained in a concentration range of 0.01 to 10 g/L in the electroplating solution.

[0014] Methanesulfonic acid and salts thereof, sulfamic acid and salts thereof, hydrochloric acid and salts thereof, and sulfuric acid and salts thereof can be cited as examples of conductive salts. The conductive salt is preferably contained in a concentration range of 5 to 300 g/L in the electroplating solution.

[0015] Sodium hydroxide, potassium hydroxide, ammonia, hydrochloric acid and sulfuric acid can be cited as examples of pH adjusters.

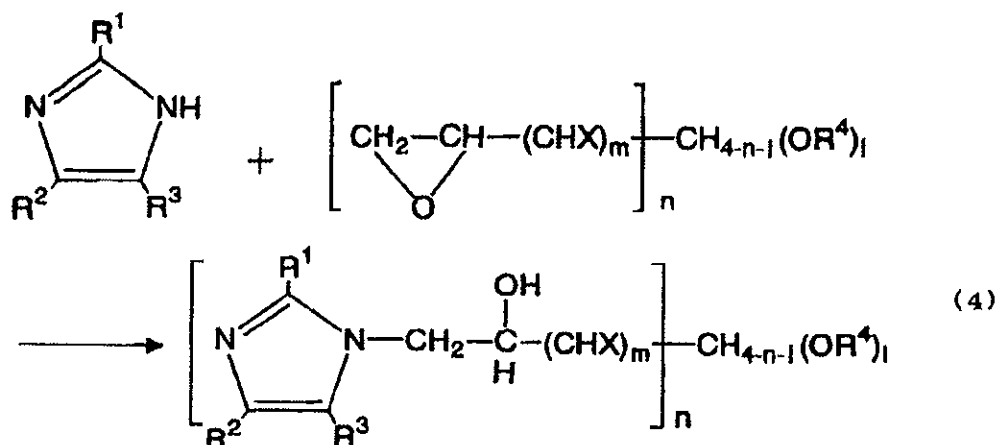
[0016] Malic acid, citric acid, gluconic acid, lactic acid, succinic acid, ethanethiol, thiourea, and ethylene diamine tetraacetic acid can be cited as examples of complexing agents. The complexing agent is preferably contained in a concentration range of 0.05 to 100 g/L in the electroplating solution.

[0017] In the present invention, one or more kinds of compounds having an imidazole group and a hydroxyl group in one molecule are added to the aforementioned tin electroplating base solution or tin alloy electroplating base solution. The aforementioned complexing agent and the compound having an imidazole group and a hydroxyl group in one molecule may be pre-mixed and then added.

[0018] In contrast to the previously described conventional tin electroplating solutions or tin alloy electroplating solution, in the present invention it is important to use a plating solution to which is added one or more kinds of compounds having an imidazole group and a hydroxyl group in one molecule. The solder wettability and external appearance of the tin plated objects or tin alloy plated objects can thereby be improved, and the plating rate can also be improved.

[0019] Preferably, the compound having an imidazole group and a hydroxyl group in one molecule used in the present invention is synthesized by the reaction represented in the following reaction formula (4),

[Chemical Formula 3]



wherein in the formula, R^1 , R^2 , R^3 , R^4 , X , l , m , and n are the same as in the previously described definitions.

[0020] If R^1 , R^2 , R^3 , and R^4 in the aforementioned general formulae (1) to (3) are a hydrogen atom, a vinyl group or an alkyl group having 1 to 20 carbon atoms, the effects of the present invention will be fully manifested. The alkyl group has 1 to 20 carbon atoms, and preferably has 1 to 9 carbons. Moreover, if R^2 and R^3 form an aromatic ring, the aromatic ring formed is preferably a benzene ring. X is a hydrogen atom, an alkyl group having 1 to 6 carbon atoms, or a substituent that may contain N, O; an alkyl group having 1 to 4 carbon atoms is preferable as the alkyl group having 1 to 6 carbon atoms; and a hydroxyl group, carboxyl group or amino group, etc. may be cited as the substituent containing N, O. In addition to the previous description R^4 is preferably a phenyl group or $-(\text{CH}_2\text{CH}(\text{R}^5)\text{O})_k\text{H}$, wherein R^5 represents a hydrogen atom, or an alkyl group having 1 to 20 carbon atoms and k is an integer of from 1 to 20.

[0021] Imidazole, 2-alkylimidazole, 2,4-dialkylimidazole, and 4-vinylimidazole, etc. are preferable as the imidazole compound represented in the

aforementioned general formula (2). If R^1 to R^3 bonded to an imidazole group are an alkyl group and the alkyl group has 10 or more carbon atoms, the wettability of the material to be plated may decrease because of strengthened hydrophobicity, and the characteristics may drop. Therefore, in these cases an alkyl group having 1 to 9 carbon atoms is preferable. Imidazole and 2-methylimidazole may be cited as preferable examples among these.

[0022] Epoxy propanol, epoxy butanol, epoxy pentanol, epoxy hexanol, methoxy glycidol, n-butoxyglycidol, tert-butoxy glycidol, phenoxy glycidol, and epoxy compounds having alkylene oxide, for example, such as glycidols with added ethylene oxide, may be cited as examples of epoxy compounds represented by the general formula (3).

[0023] The aforementioned reaction may be conducted while adding dropwise the epoxy compound into the imidazole compound heated at 80 to 200°C in a molar ratio of the epoxy compound to the imidazole compound being 0.1 to 10, and a reaction time of about 5 minutes to 3 hours is sufficient. This reaction does not always require a solvent, but an organic solvent such as chloroform, dioxane, methanol, or ethanol may be used as the reaction solvent. Further, because this reaction does not favor water or moisture, it is preferable to avoid inclusion of moisture, and to conduct the reaction in a gas atmosphere that does not contain water, such as dried nitrogen or argon.

[0024] The amount of one or more compounds having an imidazole group and a hydroxyl group in one molecule added to the plating solution is preferably from 0.01 g/L to 10 g/L, more preferably from 0.1 g/L to 5 g/L. When

the amount of addition is too small, the resulting plating film cannot be dull-finished and has a rough surface. Further, since any improved cathode current efficiency cannot be obtained, the plating rate is low and any improved solderability cannot be observed. Consequently, desired effects cannot be obtained. On the other hand, an excessive addition lowers the plating rate and deteriorates the physical properties (in regards to the oxidation resistance, solderability, soldered strength, etc.) due to inclusion of the additives into the plating film. A considerably excessive addition will result in non-plated portions in the plating film.

[0025] Next, the conditions will be described for tin electroplating and tin alloy electroplating using the plating solution of the present invention.

The plating temperature is from 10 to 50°C, preferably 20 to 45°C. Moreover, the plating solution may be used at a pH in the range from strong acid to neutral. Specifically, pH 2 to 6.5 may be used for tin-zinc plating, but this is not particularly limited. Electroplating can be conducted with an electroplating current density of 0.1 A/dm² to 30 A/dm², preferably 1 A/dm² to 15 A/dm².

Any of barrel plating, rack plating, or hoop plating may be applied as the plating method.

Examples

[0026] Next, the present invention will be explained in detail using examples.

Examples of Synthesis

Synthesis of imidazole alcohol compounds 1 to 3

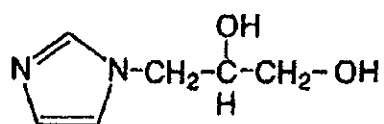
Imidazole 9.2 g was heated to 120°C, and after

adding dropwise 10 g of 2,3-epoxy propanol, was allowed to react for 3 hours at 150°C to obtain imidazole alcohol 1.

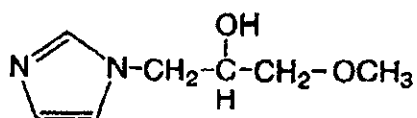
Imidazole alcohols 2 and 3 indicated below were also synthesized using the same synthesis method as above by adjusting the added mol ratio of the imidazole compound and epoxy compound to 1:1.

[0027]

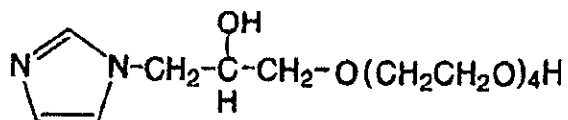
[Chemical Formula 4]



Imidazole alcohol 1



Imidazole alcohol 2



Imidazole alcohol 3

The imidazole alcohol compounds of the aforementioned structures were added to a tin plating base solution or a tin alloy plating base solution, and plating tests were conducted.

[0028] Example 1

A tin alloy electroplating base solution with the following composition was used.

[Table 1]

Composition	Amount added
Tin	15 g/L (added as a sulfonic acid salt, and the amount added is the value as tin metal)
Zinc	15 g/L (added as a sulfonic acid salt, and the amount added is the value as zinc metal)
Triethanolamine	7.5 g/L
Guaiacol	0.5 g/L
Ammonia sulfamate	100 g/L
Polyethylene glycol-polypropylene glycol block copolymer (hydrophobic group component 15%, average molecular weight 20,000)	3.0 g/L
Polyacrylamide (average molecular weight 3,000)	1.0 g/L
Aqueous ammonia	Adjusted to pH 4.5

[0029] Plating was conducted using a plating solution in which 1 g/L of the aforementioned imidazole alcohol compound 1 was added to the composition above, and the plating rate and solderability were confirmed.

Plating was conducted in a 3 dm³ beaker using a tin plate (150 x 150 x thickness 10 mm) with an anode bag as the anode while agitating with a stirrer (50 mm rotational blade, 300 rpm). The cathode was a 10 x 25 mm copper wire, and it was rocked at a stroke length of 60 mm and at 24 rpm. The plating temperature was 35°C.

The plating rate was measured for plating at the respective cathode current densities of 2, 3, 5, and 10 A/dm² by measuring the weight of the plating film and measuring the film thickness by X-ray fluorescence.

[0030] The solderability was evaluated for a predetermined plating film thickness of 5 μm obtained by

plating with a cathode current density of 5 A/dm².

A pretreatment for the solderability test was conducted in an autoclave at a temperature of 105°C and a humidity of 100% (called "PCT" hereinafter) for 4 and 16 hours, or a reflow processing was conducted at a pre-heating temperature of 160°C and a main heating temperature of 230°C for a total processing time of 3 minutes. The solderability was examined by a meniscograph method.

A flux NA-200 (manufactured by Tamara Kaken K.K.) was used to measure the zero cross time with a lead-free tin-3silver-0.5copper solder at a temperature of 240°C, immersion depth of 2 mm, and immersion velocity of 2 mm/sec.

The results of the plating rate are indicated in Table 5, and the results of the solderability are indicated in Table 7.

[0031] Example 2

[Table 2]

Composition	Amount added
Tin	20 g/L (added as a sulfonic acid salt, and the amount added is the value as tin metal)
Zinc	10 g/L (added as a sulfonic acid salt, and the amount added is the value as zinc metal)
Triethanolamine	7.5 g/L
Hydroquinone	0.5 g/L
Gluconic acid (50% aqueous solution)	100 g/L
Lactic acid (50% aqueous solution)	60 g/L
Polyethylene glycol (average molecular weight 6,000)	5.0 g/L
Polyacrylic acid (average molecular weight 6,000)	1.0 g/L
Potassium hydroxide	Adjusted to pH 2.15

[0032] Plating was conducted in the same way as in Example 1, except that a plating solution prepared by adding 3 g/L of the aforementioned imidazole alcohol compound 2 to the aforementioned composition indicated in Table 2 was used, and the plating rate, solderability, and reflow characteristics were examined. Moreover, fineness of the crystals of the plating film was measured using an electron microscope.

The reflow characteristics were evaluated by placing each tin-zinc plated test piece on an aluminum plate (thickness 0.3 mm, material 1020) and reflowing by using a hot plate. Reflow was conducted at a temperature of 230°C ±5°C for a reflow time of 30 seconds.

The results of the plating rate are indicated in Table 5; results of the solderability are in Table 7; results of the reflow characteristics are in Table 9; and

the external appearance after plating and after reflow are indicated in FIG. 1.

[0033] Example 3

[Table 3]

Composition	Amount added
Tin	15 g/L (added as a sulfonic acid salt, and the amount added is the value as tin metal)
Zinc	15 g/L (added as a sulfonic acid salt, and the amount added is the value as zinc metal)
Citric acid	50 g/L
Succinic acid	50 g/L
Hydroquinone	0.2 g/L
Polyethylene glycol-1-naphthoether (average molecular weight 600)	5.0 g/L
Polyacrylamide (average molecular weight 3,000)	1.0 g/L
Aqueous ammonia	Adjusted to pH 4.0, 6.0

[0034] Plating was conducted using a plating solution in which 1 g/L of the aforementioned imidazole alcohol compound 1 was added to the composition (pH 4.0) indicated in Table 3, and the plating rate and solderability were examined. Plating was conducted on a connector part (made of brass) having a 1 μm thick nickel undercoat at cathode current densities of 2, 3, 5, and 10 A/dm^2 and the plating rate was measured, as in Example 1. Solderability was measured and evaluated in the same way as in Example 1, except that the cathode current density and the plating film thickness were 10 A/dm^2 and 2 μm .

The results of the plating rate are indicated in Table 5, and the results of the solderability are in Table 8.

[0035] Example 4

Plating was conducted using a plating solution in which 3 g/L of the aforementioned imidazole alcohol compound 1 was added to the composition (pH 6.0) indicated in Table 3, and the plating rate and solderability were examined. Barrel plating (mini-barrel: manufactured by Yamamoto-MS Co., Ltd.) was conducted, and copper plate (10 x 25 mm) was used as the material to be plated.

Plating was conducted in the same conditions as in Example 1, except that the amount of solution was 3 liters, the plating temperature was 35°C, the plating time was 50 minutes, and the rotational velocity was 10 rpm. The plating rate and solderability were measured and evaluated in the same way as in Example 1.

The results of the plating rate are indicated in Table 5, and the results of the solderability are in Table 7.

[0036] Example 5

[Table 4-1]

Composition	Amount added
Tin	15 g/L (added as a sulfonic acid salt, and the amount added is the value as tin metal)
Zinc	15 g/L (added as a sulfonic acid salt, and the amount added is the value as zinc metal)
Citric acid	50 g/L
Succinic acid	50 g/L
Hydroquinone	0.2 g/L
Polyethylene glycol-1-naphthoether (average molecular weight 600)	5.0 g/L
Polyacrylic acid-polysulfonic acid copolymer (average molecular weight 10,000)	1.0 g/L
Aqueous ammonia	Adjusted to pH 4.0

[0037] Plating was conducted in the same way as in Example 3, except that a plating solution prepared by adding 1 g/L of the imidazole alcohol compound 1 to the composition (pH 4.0) indicated in Table 4-1 above was used, and the plating rate and solderability were examined. The fineness of the crystals of the plating film was examined by an electron microscope.

The results of the plating rate are indicated in Table 5; the results of the solderability are in Table 8; and the condition of the crystals of the plating film is indicated in FIG. 2.

[0038] Example 6

Plating was conducted in the same way as in Example 3, except that a plating solution prepared by adding 0.5 g/L of the imidazole alcohol compound 2 to the composition (pH 4.0) indicated in Table 4-1 above was

used, and the plating rate and solderability were examined.

The results of the plating rate are indicated in Table 5, and the results of the solderability are in Table 8.

[0039] Example 7

Plating was conducted in the same way as in Example 3, except that a plating solution prepared by adding 0.5 g/L of the imidazole alcohol compound 3 to the composition (pH 4.0) indicated in Table 4-1 above was used, and the plating rate and solderability were examined.

The results of the plating rate are indicated in Table 5, and the results of the solderability are in Table 8.

[0040] Example 8

Plating was conducted in the same way as in Example 3, except that a plating solution prepared by adding 5 g/L of the imidazole alcohol compound 2 to the composition (pH 4.0) indicated in Table 4-1 above was used, and the plating rate and solderability were examined.

The results of the plating rate are indicated in Table 5, and the results of the solderability are in Table 8.

[0041] Example 9

Plating was conducted in the same way as in Example 3, except that a plating solution prepared by adding 0.5 g/L of an equimolar mixture of the imidazole alcohol compound 1 and citric acid to the composition (pH 4.0) indicated in Table 4-1 above was used, and the plating rate and solderability were examined.

The results of the plating rate are indicated in Table 5, and the results of the solderability are in Table 8.

[0042] Example 10

Plating was conducted in the same way as in Example 1, except that a plating solution prepared by adding 3 g/L of the imidazole alcohol compound 1 to the composition indicated in Table 4-1 above was used, and the plating rate and solderability were examined. The results of the plating rate are indicated in Table 5, and the results of the solderability are in Table 7.

[0043] Example 11

[Table 4-2]

Composition	Amount added
Tin	25 g/L
Citric acid	50 g/L
Succinic acid	50 g/L
Hydroquinone	0.2 g/L
Polyethylene glycol-1-naphthoether (average molecular weight 600)	5.0 g/L
Polyacrylic acid-polysulfonic acid copolymer (average molecular weight 10,000)	1.0 g/L
Aqueous ammonia	Adjusted to pH 3.6

[0044] Plating was conducted in the same way as in each of Examples 1 and 3, except that a plating solution prepared by adding 0.5 g/L of the imidazole alcohol compound 1 to the composition indicated in Table 4-2 above was used, and the plating rate and solderability were examined.

The results of the plating rate are indicated in Table 5, and the results of the solderability are in Table 7.

[0045] Comparative Examples 1 to 5, 10, and 11

Plating was conducted in the same way as in Examples 1 to 5, 10, and 11, respectively, except that the plating solutions indicated in Tables 1, 2, 3 and 4 were used without addition of the imidazole alcohol compounds, and the same measurements and evaluations were conducted. The results of the plating rate are indicated in Table 6; the results of the solderability are in Tables 7 and 8; the results of reflow characteristics are in Table 9; and the condition of the crystals of the plating films obtained in Comparative Examples 2 and 5 are indicated in FIGS. 1 and 2, respectively.

Comparative Examples 1 to 5, 10 and 11 correspond to Examples 1 to 5, 10 and 11, respectively.

[0046]

[Table 5]

Plating rate Units: $\mu\text{m}/\text{min}$.

Cathode current density (A/dm ²)	Example										
	1	2	3	4	5	6	7	8	9	10	11
2	0.89	0.97	0.87	0.62	0.87	0.92	0.85	0.70	0.82	0.84	0.92
3	1.30	1.35	1.21	1.32	1.21	1.31	1.26	1.05	1.10	1.44	1.32
5	1.89	1.74	1.63	1.78	1.63	1.83	1.68	1.45	1.51	1.96	1.95
10	2.69	2.31	2.12	2.71	2.12	2.22	2.19	1.98	1.90	2.80	2.48

[0047]

[Table 6]

Plating rate (Comparative Examples) Units: $\mu\text{m}/\text{min}$.

Cathode current density (A/dm^2)	Example						
	1	2	3	4	5	10	11
2	0.82	0.49	0.52	0.44	0.51	0.62	0.48
3	0.97	0.61	0.65	0.73	0.52	0.71	0.68
5	X	0.85	0.87	0.98	0.53	0.70	X
10	X	X	X	X	X	X	X

X: Area where plating not possible (abnormal deposition, generation of burning)

[0048]

[Table 7]

Solderability (Meniscograph Method)

Data for Copper Plate

	Zero cross time (seconds)			
	Immediately after plating	PCT 4 hr	PCT 16 hr	Reflow processing
Example 1	2.23	2.67	2.76	2.63
Example 2	1.29	2.23	2.48	1.92
Example 4	1.51	2.25	2.83	1.09
Example 10	1.68	2.32	2.74	1.53
Example 11	1.26	2.22	2.47	1.66
Comparative Example 1	2.82	4.28	5 seconds or more	2.99
Comparative Example 2	3.17	4.55	5 seconds or more	3.21
Comparative Example 4	3.28	No solder wetting	No solder wetting	5 seconds or more
Comparative Example 10	2.58	No solder wetting	No solder wetting	5 seconds or more

[Table 8]

Solderability (Meniscograph Method)

Data for Connector Pin

	Zero cross time (seconds)			
	Immediately after plating	PCT 4 hr	PCT 16 hr	Reflow processing
Example 3	1.08	1.28	1.83	0.86
Example 5	1.00	1.28	1.58	1.01
Example 6	0.98	1.33	1.65	1.18
Example 7	1.02	1.36	1.62	1.09
Example 8	1.20	1.45	1.86	1.36
Example 9	0.98	1.19	1.52	1.05
Example 11	0.65	1.01	1.11	0.56
Comparative Example 3	1.68	No solder wetting	No solder wetting	5 seconds or more
Comparative Example 5	1.50	3.26	4.09	3.59

Example 11 was tin plating

[0050]

[Table 9]

Reflow Characteristics

	Immediately after plating		2 weeks after plating	
	Without flux	NA-200	Without flux	NA-200
Example 2	⊙	⊙	○	⊙
Comparative Example 2	X	X	X	X

⊙: Uniformly reflows; ○: Had a few uneven parts; X: Did not fuse, unchanged before and after processing

BRIEF DESCRIPTION OF THE DRAWINGS

[0051]

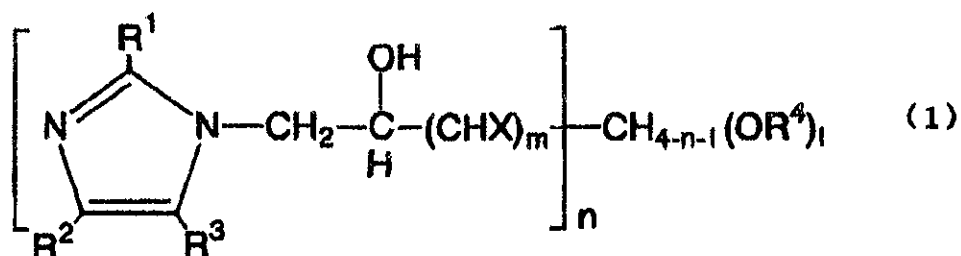
[FIG. 1] Electron microscope photographs of plating films obtained in Example 2 and Comparative Example 2; and

[FIG. 2] Electron microscope photographs of plating films obtained in Example 5 and Comparative Example 5.

CLAIMS

1 Tin and tin alloy electroplating solutions, characterized by containing one or more compounds having an imidazole group and a hydroxyl group in one molecule, wherein the compound having an imidazole group and a hydroxyl group in one molecule is an imidazole alcohol compound expressed by the following general formula (1),

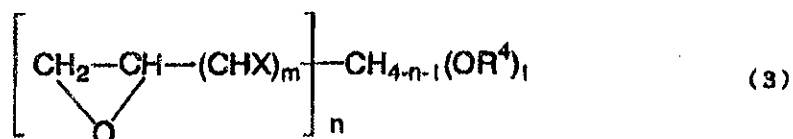
[Chemical Formula 1]



wherein in the general formula (1), R^1 , R^2 , R^3 each independently represent a hydrogen atom, a vinyl group or an alkyl group having 1 to 20 carbon atoms, and R^2 and R^3 may be joined together to form an aromatic ring; R^4 represents a hydrogen atom, a vinyl group, an alkyl group having 1 to 20 carbon atoms, a phenyl, or $-(\text{CH}_2\text{CH}(\text{R}^5)\text{O})_k\text{H}$, with R^5 representing a hydrogen atom, or an alkyl group having 1 to 20 carbon atoms and k representing an integer of from 1 to 20; X represents a hydrogen atom, an alkyl group having 1 to 6 carbon atoms, or a substituent that may contain N, O; m represents an integer of from 0 to 20; and n and l represent an integer of from 1 to 3.

2 The tin and tin alloy electroplating solutions according to claim 1, characterized in that the compound represented by the general formula (1) is an imidazole alcohol compound obtained by reacting an imidazole compound represented by the general formula (2) below with an epoxy compound represented by the general formula (3) below,

[Chemical Formula 2]



wherein in the general formulae (2) and (3), R^1 , R^2 , R^3 each independently represent a hydrogen atom, a vinyl group or an alkyl group having 1 to 20 carbon atoms, and R^2 and R^3 may be joined together to form an aromatic ring; R^4 represents a hydrogen atom, a vinyl group, an alkyl group having 1 to 20 carbon atoms, a phenyl group, or $-(\text{CH}_2\text{CH}(\text{R}^5)\text{O})_k\text{H}$, with R^5 representing a hydrogen atom or an alkyl group having 1 to 20 carbon atoms, and k representing an integer of from 1 to 20; X represents a hydrogen atom, an alkyl group having 1 to 6 carbon atoms, or a substituent that may contain N, O; m represents an integer of from 0 to 20; and n and l represent an integer of from 1 to 3.