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**BRIGHT GOLD ALLOY ELECTROPLATING
BATH AND PROCESS**

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10 Claims

ABSTRACT OF THE DISCLOSURE

An electroplating bath for effecting bright and relatively stress-free deposits of gold alloys. The bath is an aqueous solution of a soluble gold-alkali metal cyanide and a weak, stable, partially neutralized organic acid, together with quantities of cyclohexylamine and small amounts of soluble base metal salts or complexes to provide the desired alloy. A buffering agent for stabilizing the pH of the bath may also be incorporated into the bath.

BACKGROUND OF INVENTION

This invention relates generally to electroplating baths and compositions, and more specifically relates to such baths and compositions as are useful in the electroplating of gold alloys.

Numerous gold alloy electroplating compositions are known in the art, which function in the presence of mildly acidic conditions and yield deposits of good quality—provided, however, that the thicknesses of the deposits are maintained quite low. In the case of many such prior compositions, it is thus found that as plating thicknesses increase beyond typical values of the order of one to several microns, internal stresses develop, and in turn effect cracking and porosity in the deposit, and consequent poor adhesion to the underlying substrate.

It has also been long observed that deposits effected by many of the aforementioned compositions tended to lose their uniformity of color in consequence of nodule build-up during the course of deposition. Such compositions, moreover, tend to display an inability to provide satisfactory deposits—especially with respect to brightness and uniformity—over a reasonably extended pH range. In order to compensate for this latter limitation, careful attention must be paid to processing conditions, in turn demanding an undesirable investment in equipment and operator time.

In accordance with the foregoing, it may be regarded as an object of the present invention, to provide a gold alloy plating bath, which enables production of uniform and relatively stress-free deposits, even where the deposits are of relatively high thickness.

It is a further object of the invention, to provide a gold alloy plating bath composition, which produces deposits of excellent brightness, and with relatively slight nodule build-up.

It is an additional object of the invention, to provide a gold alloy electroplating bath, which functions with a high degree of efficacy over an extended acidic pH range, and up to relatively elevated temperatures.

SUMMARY OF INVENTION

Now in accordance with the present invention, it has been discovered that the foregoing objects, and others as will become apparent in the course of the ensuing specification, are achieved in a plating bath incorporating quantities of cyclohexylamine in an acid gold plating solution containing gold in the form of an alkali metal cyanide, together with a weak, stable, partially neutralized organic acid, and soluble salts or complexes

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of base metals such as antimony, arsenic, zinc, indium, cobalt, nickel, and/or others as are known in the art to be useful in providing gold alloy platings.

The bath may be effectively operated in the pH range from about 2.5 to at least 6.0, and at temperatures up to at least 50° C.

DESCRIPTION OF PREFERRED EMBODIMENT

The efficacy of the electroplating bath resulting from addition of quantities of cyclohexylamine may be appreciated from the following examples:

Example I

An electrolytic bath was prepared by dissolving in water the following components:

Gold metal (as potassium gold cyanide)	-----g./l.	8
Citric acid	-----g./l.	30
Potassium citrate	-----g./l.	60
Cobalt (as sulfate)	-----g./l.	2
Cyclohexylamine	-----ml./l.	10

The pH of this bath was adjusted with citric acid or potassium hydroxide to about 6.0. A test panel of 1 x 1.5" was plated at a current density of 10 amperes/square foot and at 32° C., and was fully bright. The agitation was moderate.

Example II

An electrolytic bath was prepared by dissolving in water the following components:

Gold metal (as potassium gold cyanide)	-----g./l.	8
Citric acid	-----g./l.	20
Potassium citrate	-----g./l.	80
Nickel (as sulfate)	-----g./l.	3
Cyclohexylamine	-----ml./l.	30

The pH of the bath was adjusted with citric acid or potassium hydroxide to about 5.2. A panel plated at 10 amp/square foot for 20 minutes was found to be fully bright.

Examples I and II, above, were both conducted with the bath compositions set forth maintained at approximate temperatures of 32° C. The said compositions are effective formulations at higher temperatures, however, up to at least 50° C. Utilizing, for example, a bath identical in composition to that of Example II, but maintained at 50° C. and at a pH of 5.8, it was found that a panel plated at 2.5 amp/square foot was fully bright after 10 minutes. The efficiency in such bath, calculated as a percentage of theoretical gold deposit, was found to be 51.8.

Example III

An electrolytic bath was prepared by dissolving in water the following components:

Gold metal (as potassium gold cyanide)	-----g./l.	8
Citric acid	-----g./l.	30
Potassium citrate	-----g./l.	50
Cobalt (as sulfate)	-----g./l.	2
Indium (as sulfate)	-----g./l.	2
Cyclohexylamine	-----ml./l.	5

The pH was adjusted to 4.0 and a panel plated at a current density of 10 amp/square foot for 2 hours. The resulting plating was fully bright and very uniform.

The amount of cyclohexylamine utilized in accordance with the invention is normally selected on the basis of resulting improvement in the metal deposits—particularly improvement in the brightness of said deposits. It is found that a preferable range of addition is in the approximate range of from about 1 to 50 ml./l. The amount of gold utilized in the present composition, present as sodium or potassium gold cyanide, is normal-

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ly in the range of about 2 to 60 g./l. calculated as metal. The organic acid is typically present in quantities from about 10 to 150 g./l. Excellent plating results are furthermore achieved throughout a pH range of from about 2.5 to 6.0.

In addition to the cobalt, nickel, and indium set forth in the above examples, other base metals may be added to the plating baths of the invention, in the forms of their soluble salts and metal complexes compatible with the formulation desired. Included in such additional metals are, for example, the elements antimony and arsenic, all such elements being added either individually or in combination. Such metals may be effectively utilized in amounts up to about 60 g./l. calculated as the metal.

In order to stabilize the pH in the baths of the invention, it may also be desirable in some instances to add quantities of buffering agents to the bath. Various agents, as are known in the art, may be utilized for such purposes including, for example, water soluble tartrates, borates, oxalates or so forth. Typically, an alkali phosphate may be added to the extent of about 15 to 75 g./l.

One of the significant advantages of the present invention resides in the fact that the processes set forth may be conducted at relatively elevated temperatures. More specifically, it is found that utilizing the aforementioned baths good plating results are achieved at temperatures up to at least 50° C. This result, in turn, means that higher efficiency in the plating process is achievable with consequent decrease in the plating time required to deposit a given thickness.

While the present invention has been particularly set forth in terms of specific embodiments thereof, it will be understood in view of the instant disclosure, that numerous variations upon the invention are now enabled to those skilled in the art, which variations in propriety, yet reside within the true scope of the instant teaching. Accordingly, the invention is to be broadly construed, and limited only by the scope and spirit of the claims now appended hereto.

We claim:

1. An electroplating bath for electrolytically depositing bright and relatively stress-free deposits of gold-base metal alloys, comprising: an aqueous acidic solution of a soluble gold-alkali metal cyanide, a weak stable partially neutralized organic acid, an alloying agent selected from the group consisting of the bath soluble salts and complexes of the base metal desired to be alloyed with said gold being present in an amount up to 60 g./l. calculated as the metal, and quantities of cy-

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clohexylamine sufficient to provide a brighter and more stress-free deposit than is obtained in the absence thereof.

2. A composition according to claim 1, wherein said acid is partially neutralized to yield a pH in the range of 2.5 to 6.0, and said cyclohexylamine is present in the range from about 1 to 50 ml./l.

3. A composition according to claim 2, wherein said alloying agent is a salt selected from one or more members of the group consisting of the bath soluble salts of cobalt, nickel, indium, antimony and arsenic.

4. A composition according to claim 3 wherein said alloying agent comprises a salt of cobalt.

5. A composition according to claim 3 wherein said alloying agent comprises a salt of nickel.

6. A composition according to claim 3 wherein said alloying agent comprises the salts of cobalt and indium.

7. A composition according to claim 2, further including sufficient quantities of an additional buffering agent to maintain a stable pH.

8. A method for electroplating bright, relatively thick and stress-free deposits of a gold-base metal alloy, comprising:

electrolyzing an aqueous acidic solution of a soluble gold alkali metal cyanide, a weak stable partially neutralized organic acid, an alloying agent selected from the group consisting of the bath soluble salts and complexes of the base metal desired to be alloyed with said gold being present in an amount up to 60 g./l. calculated as the metal, and quantities of cyclohexylamine sufficient to provide a brighter and more stress-free deposit than is obtained in the absence thereof.

9. A method according to claim 8, wherein said process is conducted at a pH range between about 2.5 to 6.0.

10. A method according to claim 9, wherein said process is conducted until a plating deposit exceeding 5 microns in average depth is effected.

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