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(54) COATING STRUCTURE COMPRISING GRAPHITE COMPOSITE AND PREPARATION METHOD

(57) The present invention provides a coating structure. The coating structure comprises a substrate, a first metal layer, a second alloy layer, a third metal layer, and a fourth alloy layer. The first metal layer is plated on the outside of the substrate, and does not include graphite. The second alloy layer is plated on the outside of the first metal layer, and includes an alloy synthesized from graphite and metal. The third metal layer is plated on the outside of the second alloy layer, and does not include graphite. The fourth alloy layer is plated on the outside of the third metal layer, and includes an alloy synthesized from graphite and metal. By arranging the metal layers without graphite and the alloy layers with graphite to be repeated in a stack, the coating structure can be arranged to any desired thickness, and seal graphite alloy within its structure, thereby preventing graphite particles from floating in the air. Furthermore, the present invention further provides a preparation method for a coating structure.

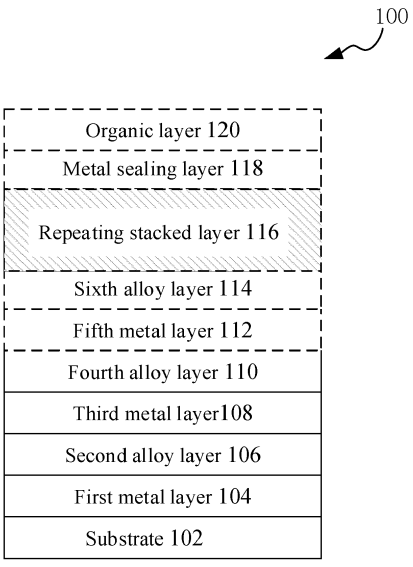

FIG. 1

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Description

FIELD OF THE DISCLOSURE

[0001] The present disclosure relates to electroplating field, more particularly to a coating structure comprising graphite alloy and a preparation method.

BACKGROUND

[0002] Various metal coatings are widely used on components for electronics, healthcare, locomotives, aviation, and navigation. With the rapid development of the performance of components, people have more demanding requirements for electrical conductivity, thermal conductivity, wear resistance, corrosion resistance, and solderability performances, etc., of metal coating. It has been found that using graphite alloy to manufacture coating can increase its lubricity and wear resistance, resulting in a lower friction coefficient with improved electrical conductivity, thermal conductivity, and wear resistance properties.

[0003] However, the non-polarity of graphite makes it non-hydrophilic, and during the preparation process of graphite alloy, it is easy for graphite to separate and precipitate. This results in an uneven distribution of graphite in the coating. Graphite is prone to be distributed in the superficial layer of the coating, and adhesion of the coating decreases as the content of graphite increases. The deposition quality and efficiency of the coating are not high. Moreover, as graphite partially precipitates during the preparation process, free graphite dust can be harmful to human health. People who inhale it for a long time may suffer allergic asthma and dust-related diseases. Current methods for preparing graphite alloy have other drawbacks, such as a narrow working window for plating solution, limited thickness of coating, and difficulty in industrial mass production.

SUMMARY

[0004] To solve the problem above, the present invention proposes a coating structure that seals the graphite alloy inside its structure, which can prevent the graphite particles in the coating from floating in the air.

[0005] Based on that, a coating structure is provided according to an embodiment of the present invention. The coating structure comprises a substrate, a first metal layer, a second alloy layer, a third metal layer, and a fourth alloy layer. The first metal layer is plated on the outside of the substrate, and does not include graphite. The second alloy layer is plated on the outside of the first metal layer, and includes an alloy synthesized from graphite and metal. The third metal layer is plated on the outside of the second alloy layer, and does not include graphite. The fourth alloy layer is plated on the outside of the third metal layer, and includes an alloy synthesized from graphite and metal.

[0006] In this embodiment, by arranging the metal layers without graphite and the alloy layers with graphite to be repeated in a stack, the coating structure can be arranged to any desired thickness, meeting the requirements of practical applications. In addition, the metal layer without graphite can also serve as a sealing layer, especially in the case that the coating structure wears, as it can prevent graphite particles within the coating from floating in the air, thereby avoiding hazards to human health.

[0007] In an embodiment, the coating structure further includes a fifth metal layer and a sixth alloy layer. The fifth metal layer is plated on the outside of the fourth alloy layer, and does not include graphite. The sixth alloy layer is plated on the outside of the fifth metal layer, and includes an alloy synthesized from graphite and metal.

[0008] In an embodiment, the coating structure further includes an organic layer covered on the outermost side of the coating structure.

[0009] In an embodiment, the coating structure further includes a metal sealing layer plated on the secondary outer side of the coating structure.

[0010] In an embodiment, the first metal layer and the third metal layer each include: a single layer or multiple stacked layers of a silver layer, a gold layer, a tin layer, a platinum layer, a nickel layer, a palladium layer, a silver alloy layer, a gold alloy layer, a tin alloy layer, a platinum alloy layer, a nickel alloy layer, and a palladium alloy layer. The second alloy layer and the fourth alloy layer each include: a single layer or multiple stacked layers of an alloy layer synthesized from at least graphite and silver, an alloy layer synthesized from at least graphite and gold, an alloy layer synthesized from at least graphite and tin, an alloy layer synthesized from at least graphite and nickel, an alloy layer synthesized from at least graphite and palladium, an alloy layer synthesized from at least graphite and antimony, and an alloy layer synthesized from at least graphite and bismuth.

[0011] A preparation method for a coating structure is provided according to an embodiment of the present invention. The method comprises plating a first metal layer on the outside of a substrate, wherein the first metal layer does not include graphite; mixing colloid including graphite, with electroplating solution including second metal ions; making the mixed electroplating solution including the second metal ions, electrodeposited on the outside of the first metal layer, to obtain a second alloy layer synthesized from graphite and the second metal.

[0012] In an embodiment, the colloid including graphite is obtained by adding graphite particles to colloid including Sn^{2+} and Pd^{2+}, and stirring them well

[0013] In an embodiment, the method further comprises using ultrasonic water cleaning to remove graphite particles on a surface of the second alloy layer.

[0014] In an embodiment, the method further comprises plating a third metal layer on the outside of the second alloy layer, wherein the third metal layer does not include graphite; mixing colloid including graphite, with electro-

plating solution including fourth metal ions; and making the mixed electroplating solution including the fourth metal ions, electrodeposited on the outside of the third metal layer, to obtain a fourth alloy layer synthesized from graphite and the fourth metal.

[0015] In an embodiment, the first metal layer includes a single layer or multiple stacked layers of a silver layer, a gold layer, a tin layer, a platinum layer, a nickel layer, a palladium layer, a silver alloy layer, a gold alloy layer, a tin alloy layer, a platinum alloy layer, a nickel alloy layer, and a palladium alloy layer. The second alloy layer includes a single layer or multiple stacked layers of an alloy layer synthesized from at least graphite and silver, an alloy layer synthesized from at least graphite and gold, an alloy layer synthesized from at least graphite and tin, an alloy layer synthesized from at least graphite and nickel, an alloy layer synthesized from at least graphite and palladium, an alloy layer synthesized from at least graphite and antimony, and an alloy layer synthesized from at least graphite and bismuth.

[0016] In an embodiment, the method further comprises covering an organic layer on the outermost side of the coating structure.

[0017] In an embodiment, the method further comprises plating a metal sealing layer on the secondary outer side of the coating structure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The other features and advantages of the present invention will be better understood in conjunction with the accompanying drawings and with reference to the following detailed description of preferred embodiments. In the drawings:

FIG. 1 is a schematic diagram of a coating structure according to an embodiment of the present invention.

FIG. 2 is an exemplary flowchart of the method for preparing a coating structure according to an embodiment of the present invention.

DETAILED DESCRIPTION

[0019] The technical solution of the present disclosure is described in detail below through embodiments and in conjunction with the accompanying drawings. The same or similar reference numerals throughout the description indicate the same or similar components. The following description of the embodiments of the present disclosure with reference to the accompanying drawings is intended to explain the overall inventive concept of the present disclosure and should not be construed as a limitation to the present disclosure.

[0020] The terms "includes", "comprises" and the like used in the present disclosure should be interpreted as open-ended terms, i.e., "includes/comprises but is not limited to", indicating that other elements may also be included. The term "based on" indicates "at least partly based on". The term "one embodiment" indicates "at least one embodiment". The term "another embodiment" indicates "at least one additional embodiment".

[0021] FIG. 1 shows a schematic diagram of a coating structure according to an embodiment of the present invention. The coating structure 100 at least comprises a substrate 102, a first metal layer 104, a second alloy layer 106, a third metal layer 108, and a fourth alloy layer 110.

[0022] The substrate 102 may be metal or non-metal substrate material, such as copper, nickel, plastic, polymer material, etc., and the substrate 102 may also be a substrate coating, such as copper coating, nickel coating, etc.

[0023] The first metal layer 104 is plated on the outside of the substrate 102, and the first metal layer does not include graphite. The first metal layer 104 may be pure metal or alloy. The first metal layer 104 may include a single layer or multiple stacked layers of a silver layer, a gold layer, a tin layer, a platinum layer, a nickel layer, a palladium layer, a silver alloy layer (such as silver-tin alloy), a gold alloy layer (such as gold-cobalt alloy or gold-nickel alloy), a tin alloy layer, a platinum alloy layer, a nickel alloy layer (such as nickelphosphorus alloy), and a palladium alloy layer (such as palladium-nickel alloy). For example, the first metal layer 104 may be a silver layer, a silver layer and a gold layer in a stack, or a silver layer and a silver-tin alloy layer in a stack.

[0024] A second alloy layer 106 is plated on the outside of the first metal layer 104, and the second alloy layer 106 includes an alloy synthesized from graphite and metal. The second alloy layer 106 includes a single layer or multiple stacked layers of an alloy layer synthesized from at least graphite and silver (such as silver graphite or silver-tin graphite), an alloy layer synthesized from at least graphite and gold (such as gold graphite or gold-cobalt graphite), an alloy layer synthesized from at least graphite and tin (such as tin graphite), an alloy layer synthesized from at least graphite and nickel (such as nickel graphite or palladium-nickel graphite), an alloy layer synthesized from at least graphite and palladium (such as silver-palladium graphite), an alloy layer synthesized from at least graphite and antimony, and an alloy layer synthesized from at least graphite and bismuth. For example, the second alloy layer 106 may be a silver-tin graphite layer, or a silver graphite layer and a tin graphite layer in a stack. The first metal layer 104 can provide a structure similar to the second alloy layer 106 for plating and reducing face tension, so that the second alloy layer 106 can be closely combined with the first metal layer 104. Compared to plating the second alloy layer 106 directly on the substrate 102, the arrangement of the first metal layer 104 can solve the problem of weak adhesive when the graphite alloy is combined directly with the substrate 102.

[0025] The third metal layer 108 is plated on the outside of the second alloy layer 106, and the third metal layer 108 does not include graphite. The arrangement of the

third metal layer 108 is similar to that of the first metal layer 104. In particular, the third metal layer 108 may include a single layer or multiple stacked layers of a silver layer, a gold layer, a tin layer, a platinum layer, a nickel layer, a palladium layer, a silver alloy layer, a gold alloy layer, a tin alloy layer, a platinum alloy layer, a nickel alloy layer, and a palladium alloy layer.

[0026] The fourth alloy layer 110 is plated on the outside of the third metal layer 108, and the fourth alloy layer 110 includes an alloy synthesized from graphite and metal. The arrangement of the fourth alloy layer 110 is similar to that of the second alloy layer 106. In particular, the fourth alloy layer 110 may include a single layer or multiple stacked layers of an alloy layer synthesized from at least graphite and silver, an alloy layer synthesized from at least graphite and gold, an alloy layer synthesized from at least graphite and tin, an alloy layer synthesized from at least graphite and nickel, an alloy layer synthesized from at least graphite and palladium, an alloy layer synthesized from at least graphite and antimony, and an alloy layer synthesized from at least graphite and bismuth.

[0027] Optionally, the coating structure 100 may include a fifth metal layer 112. The fifth metal layer 112 is plated on the outside of the fourth alloy layer 110, and the fifth metal layer 112 does not include graphite. The arrangement of the fifth metal layer 112 is similar to that of the first metal layer 104.

[0028] Optionally, the coating structure 100 may include a sixth alloy layer 114. The sixth alloy layer 114 is plated on the outside of the fifth metal layer 112, and the sixth alloy layer 114 includes an alloy synthesized from graphite and metal. The arrangement of the sixth alloy layer 114 is similar to that of the second alloy layer 106.

[0029] Optionally, the coating structure 100 further includes a repeating stacked layer 116. The repeating stacked layer 116 includes a pair or multiple pairs of a metal and an alloy layers in a stack. For example, the repeating stacked layer 116 can include a pair of a metal and an alloy layers in a stack, wherein the arrangement of the metal layer is similar to that of the first metal layer 104, and the arrangement of the alloy layer is similar to that of the second alloy layer 106.

[0030] It should be noted that all the metal layers in the coating structure 100, namely the first metal layer 104, the third metal layer 108, the fifth metal layer 112, and the metal layers in the repeating stacked layer 116, may have the same or different structure and coating composition. Similarly, all the alloy layers in the coating structure 100, namely the second alloy layer 106, the fourth alloy layer 110, the sixth alloy layer 114, and the alloy layers in the repeating stacked layer 116, may have the same or different structure and coating composition. By arranging the metal layers without graphite and the alloy layers with graphite to be repeated in a stack, the coating structure 100 can be arranged to any desired thickness, meeting the requirements of practical applications. In addition, the metal layer without graphite can also serve as a sealing layer, especially in the case that the coating structure 100 wears, as it can prevent graphite particles within the coating from floating in the air, thereby avoiding hazards to human health.

[0031] Optionally, the coating structure 100 further includes a metal sealing layer 118. The metal sealing layer 118 is plated on the secondary outer side of the coating structure 100, which may be a silver layer, a tin layer, or a silver-tin alloy layer, for sealing the coating structure.

[0032] Optionally, the coating structure 100 further includes an organic layer 120. The organic layer 120 is covered on the outermost side of the coating structure 100, which may be sealing agent or lubricating oil, etc.

[0033] FIG. 2 illustrates an exemplary preparation method of the coating structure 100 according to an embodiment of the present invention. The preparation method 200 can be applied to production lines of high-speed continuous plating, barrel plating, and rack plating. If the coating structure 100 is to be prepared on an odd part, then the odd part requires to hang on the rack or be put in the barren. If the coating structure 100 is to be prepared on a continuous strip or a conveyor belt, then the roll of the strip or belt requires to be loosen and it enters into the plating line, wherein the plating line may be straight line or S-type line.

[0034] Step S202: a first metal layer 104 is plated on the outside of the substrate 102, wherein the first metal layer 104 does not include graphite. In this embodiment, the first metal layer 104 is obtained by flash plating. In other embodiments, other metal plating techniques such as chemical plating and hot dipping can also be used to obtain the first metal layer 104.

[0035] Step S204: colloid including graphite is mixed with electroplating solution including second metal ions. In particular, graphite particles are added to colloid including $Sn^{2+}$and Pd^{2+} and well stirred, to obtain the colloid including graphite. For example, an acidic colloidal solution of stannous chloride and palladium chloride is firstly prepared, and then anionic dispersant such as sodium hexametaphosphate or sodium stannate is added to mix with the solution to obtain a homogeneous and stable colloid. Alternatively, Sn^{2+} is added to colloid palladium, wherein the concentrations of Sn^{2+} and Pd^{2+} are adjusted. Then, micro- or nano-sized graphite is added to the colloid and stirred thoroughly to obtain the colloid including graphite. To obtain the second alloy layer 106 of silver-tin graphite, this embodiment mixes the colloid including graphite with an electroplating solution including second metal ions (namely Ag^{+} and Sn^{2+}). In other example, in order to obtain other types of graphite alloys, the colloid including graphite is mixed with an electroplating solution containing other second metal ions (such as gold ions, nickel ions, etc.)

[0036] Step S206: the mixed electroplating solution including the second metal ions is used to be electrodeposited on the outside of the first metal layer 104, to obtain a second alloy layer 106 synthesized from graphite and the second metal. During the process of electrodeposition, the second metal ions (namely Ag^{+} and Sn^{2+}) and

graphite are deposited together on the outside of the first metal layer 104, thereby obtaining the second alloy layer 106 of silver-tin graphite.

[0037] Step S208: ultrasonic water cleaning is used to remove graphite particles on the surface of the second alloy layer 106.

[0038] Optionally, the embodiment continues to perform step S210 that a third metal layer 108 is plated on the outside of the second alloy layer 106, wherein the third metal layer 108 does not include graphite. The execution of this step can be referred to step S202.

[0039] Optionally, the embodiment continues to perform step S212 that colloid including graphite is mixed with electroplating solution including fourth metal ions. The execution of this step can be referred to step S204.

[0040] Optionally, the embodiment continues to perform step S214 that the mixed electroplating solution including the fourth metal ions is used to be electrodeposited on the outside of the third metal layer 108, to obtain a fourth alloy layer 110 synthesized from graphite and the fourth metal. The execution of this step can be referred to step S206.

[0041] Optionally, the embodiment continues to perform step S216 that ultrasonic water cleaning is used to remove graphite particles on a surface of the fourth alloy layer 110. The execution of this step can be referred to step S208.

[0042] Optionally, the embodiment performs steps S210- S216 repeatedly.

[0043] Further, the embodiment performs step S218 that a metal sealing layer 118 is plated on the secondary outer side of the coating structure 100.

[0044] Further, the embodiment performs step S220 that an organic layer 120 is covered on the outermost side of the coating structure 100.

[0045] After completing the preparation method above, the odd part can be taken out of the rack or the barren, or the roll of the continuous strip or the conveyor belt can be collected. In the preparation method above, metal and graphite are deposited together by utilizing graphite colloid, thereby obtaining graphite alloy. This method can be used to prepare the second alloy layer 106 including graphite alloy. The second alloy layer 106 may include a single layer or multiple stacked layers of an alloy layer synthesized from at least graphite and silver, an alloy layer synthesized from at least graphite and gold, an alloy layer synthesized from at least graphite and tin, an alloy layer synthesized from at least graphite and nickel, an alloy layer synthesized from at least graphite and palladium, an alloy layer synthesized from at least graphite and antimony, and an alloy layer synthesized from at least graphite and bismuth. The advantages of this method for preparing graphite alloy include a wide working window for the plating solution, high deposition efficiency, stable quality of the coating, and feasibility on industrial mass production. Additionally, in the preparation method above, the step of cleaning graphite particles can prevent people from easily contacting with graphite particles when using the coating structure.

[0046] Although the present invention has been described herein with reference to specific examples, these specific examples are only intended to be exemplary and not to limit the present invention. It is obvious to those skilled in the art that the disclosed embodiments may be changed, added or deleted without departing from the spirit and scope of the invention.

Claims

1. A coating structure, comprising:

   a substrate;
   a first metal layer plated on the outside of the substrate, wherein the first metal layer does not include graphite;
   a second alloy layer plated on the outside of the first metal layer, wherein the second alloy layer includes an alloy synthesized from graphite and metal;
   a third metal layer plated on the outside of the second alloy layer, wherein the third metal layer does not include graphite; and
   a fourth alloy layer plated on the outside of the third metal layer, wherein the fourth alloy layer includes an alloy synthesized from graphite and metal.

2. The coating structure according to claim 1, further comprising:

   a fifth metal layer plated on the outside of the fourth alloy layer, wherein the fifth metal layer does not include graphite; and
   a sixth alloy layer plated on the outside of the fifth metal layer, wherein the sixth alloy layer includes an alloy synthesized from graphite and metal.

3. The coating structure according to either claim 1 or claim 2, further comprising:
   an organic layer covered on the outermost side of the coating structure.

4. The coating structure according to either claim 1 or claim 2, further comprising:
   a metal sealing layer plated on the secondary outer side of the coating structure.

5. The coating structure according to claim 1, wherein the first metal layer and the third metal layer each include: a single layer or multiple stacked layers of a silver layer, a gold layer, a tin layer, a platinum layer, a nickel layer, a palladium layer, a silver alloy layer, a gold alloy layer, a tin alloy layer, a platinum alloy layer, a nickel alloy layer, and a palladium alloy

layer;
and wherein the second alloy layer and the fourth alloy layer each include: a single layer or multiple stacked layers of an alloy layer synthesized from at least graphite and silver, an alloy layer synthesized from at least graphite and gold, an alloy layer synthesized from at least graphite and tin, an alloy layer synthesized from at least graphite and nickel, an alloy layer synthesized from at least graphite and palladium, an alloy layer synthesized from at least graphite and antimony, and an alloy layer synthesized from at least graphite and bismuth.

6. A preparation method for a coating structure, the method comprising:

plating a first metal layer on the outside of a substrate, wherein the first metal layer does not include graphite;
mixing colloid including graphite, with electroplating solution including second metal ions; and making the mixed electroplating solution including the second metal ions, electrodeposited on the outside of the first metal layer, to obtain a second alloy layer synthesized from graphite and the second metal.

7. The preparation method according to claim 6, wherein the colloid including graphite is obtained by:
adding graphite particles to colloid including Sn^{2+} and Pd^{2+} , and stirring them well.

8. The preparation method according to claim 6, the method further comprising:
using ultrasonic water cleaning to remove graphite particles on a surface of the second alloy layer.

9. The preparation method according to claim 8, the method further comprising:

plating a third metal layer on the outside of the second alloy layer, wherein the third metal layer does not include graphite;
mixing colloid including graphite, with electroplating solution including fourth metal ions; and making the mixed electroplating solution including the fourth metal ions, electrodeposited on the outside of the third metal layer, to obtain a fourth alloy layer synthesized from graphite and the fourth metal.

10. The preparation method according to claim 6, wherein the first metal layer includes: a single layer or multiple stacked layers of a silver layer, a gold layer, a tin layer, a platinum layer, a nickel layer, a palladium layer, a silver alloy layer, a gold alloy layer, a tin alloy layer, a platinum alloy layer, a nickel alloy layer, and a palladium alloy layer;
and wherein the second alloy layer includes: a single layer or multiple stacked layers of an alloy layer synthesized from at least graphite and silver, an alloy layer synthesized from at least graphite and gold, an alloy layer synthesized from at least graphite and tin, an alloy layer synthesized from at least graphite and nickel, an alloy layer synthesized from at least graphite and palladium, an alloy layer synthesized from at least graphite and antimony, and an alloy layer synthesized from at least graphite and bismuth.

11. The preparation method according to claim 6, the method further comprising:
covering an organic layer on the outermost side of the coating structure.

12. The preparation method according to claim 6, the method further comprising:
plating a metal sealing layer on the secondary outer side of the coating structure.

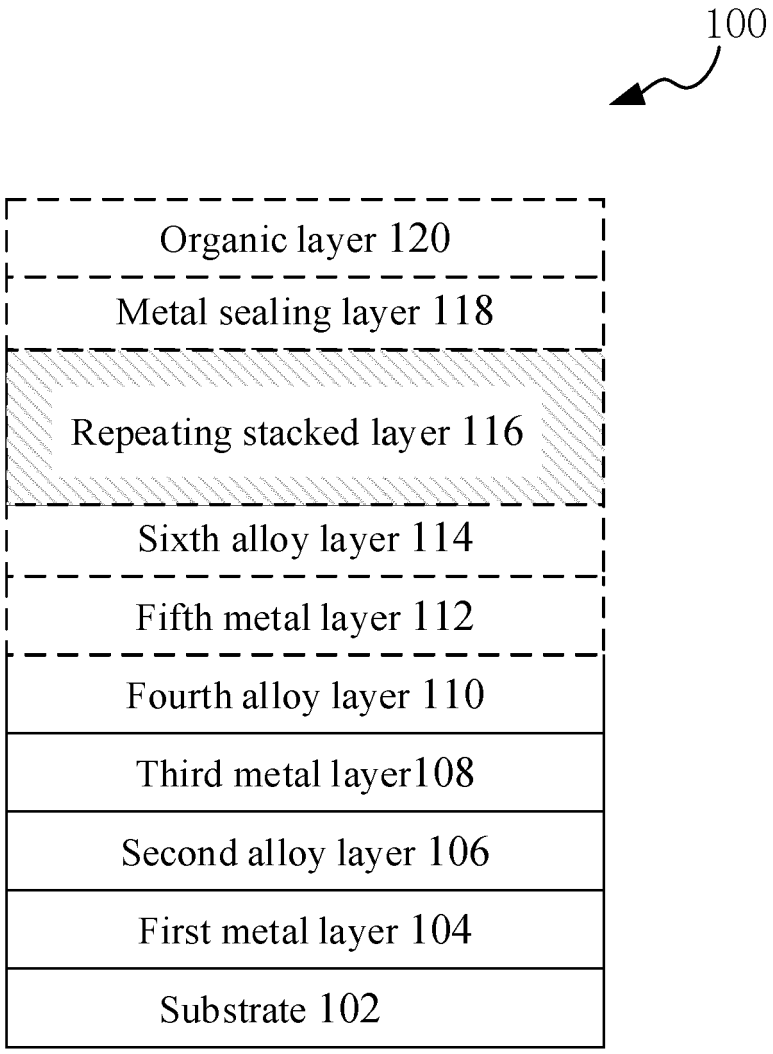
100
Organic layer 120
Metal sealing layer 118
Repeating stacked layer 116
Sixth alloy layer 114
Fifth metal layer 112
Fourth alloy layer 110
Third metal layer108
Second alloy layer 106
First metal layer 104
Substrate 102

FIG. 1

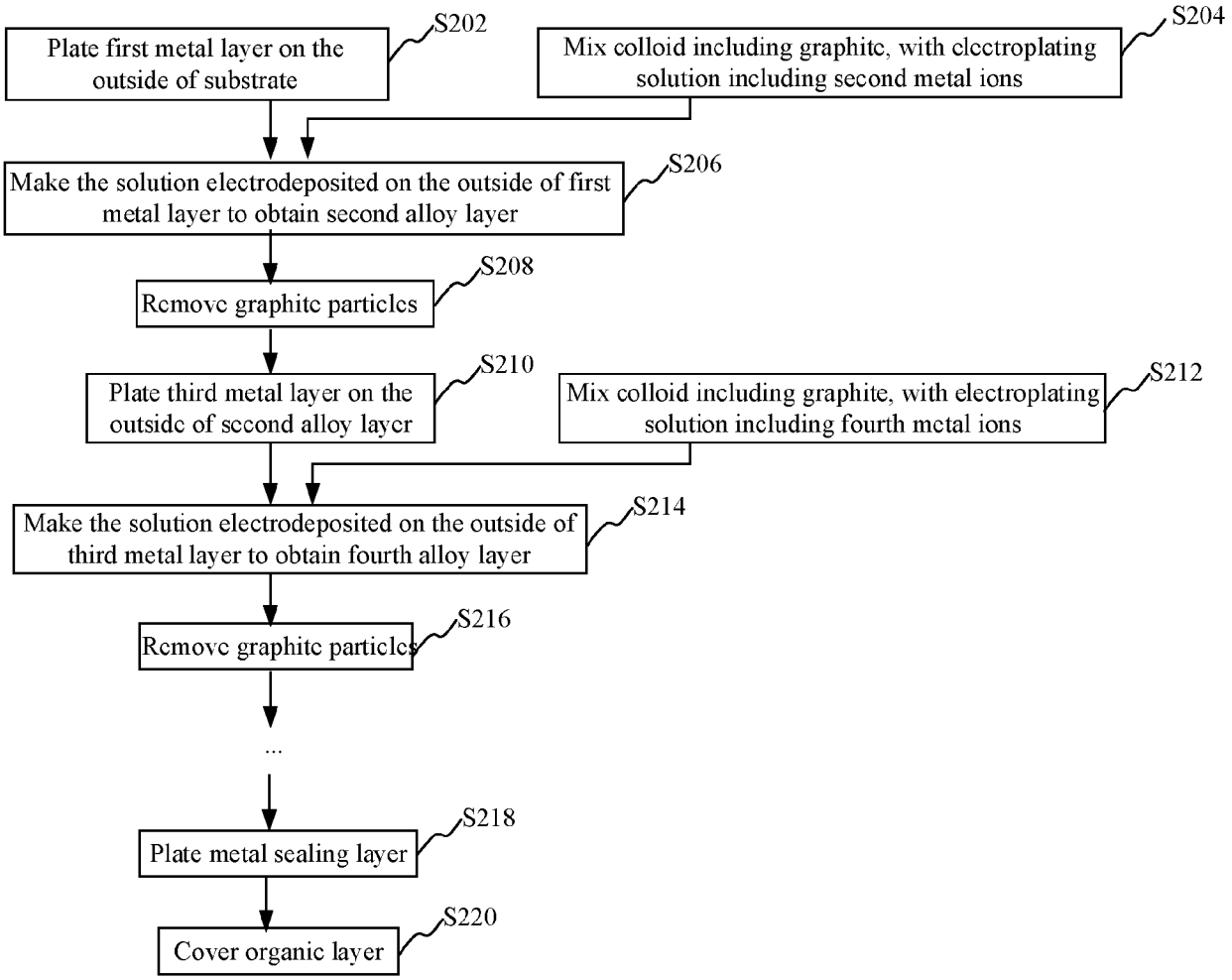
Plate first metal layer on the outside of substrate
S202
Mix colloid including graphite, with electroplating solution including second metal ions
S204
Make the solution electrodeposited on the outside of first metal layer to obtain second alloy layer
S206
Remove graphite particles
S208
Plate third metal layer on the outside of second alloy layer
S210
Mix colloid including graphite, with electroplating solution including fourth metal ions
S212
Make the solution electrodeposited on the outside of third metal layer to obtain fourth alloy layer
S214
Remove graphite particles
S216
...
Plate metal sealing layer
S218
Cover organic layer
S220

FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 23 21 5205

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	CN 110 885 995 A (UNIV JIANGSU NORMAL) 17 March 2020 (2020-03-17) * paragraph [0012] - paragraph [0016]; figure 3 *	1,2,4, 6-9,12	INV. C25D5/10 C25D5/12 C25D15/00 C25D5/14
X Y	JP 2012 057212 A (FURUKAWA ELECTRIC CO LTD) 22 March 2012 (2012-03-22) * paragraph [0018]; figure 4 * * paragraph [0022] * * paragraph [0028] *	1,2, 4-10,12 3,11	
Y	JP 2003 183882 A (KOBE STEEL LTD) 3 July 2003 (2003-07-03) * paragraph [0006] - paragraph [0008] * * paragraph [0025] *	3,11	

TECHNICAL FIELDS SEARCHED (IPC)

C25D
H01R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	14 May 2024	Telias, Gabriela

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 21 5205

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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14-05-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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JP 2003183882 A	03-07-2003	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82