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ELECTRICAL TERMINAL WITH METAL CONDUCTIVE LAYER COMPRISING SILVER

- (57)

An electrical terminal 2, 4 comprising a substrate 6 and a metallic conductive layer 8 provided on the substrate 12. The electrical terminal may be a male or female electrical terminal. The metallic conductive layer 8 has either: a silver layer 14 and an intermetallic phase 10 of silver 14 and any one or a combination of the group comprising: indium 16, gallium or tin, or; a silver layer and a bismuth layer. The intermetallic phase 10 or bismuth layer protects the silver from environmental degradation. A method of manufacturing the male or female electrical terminals 2, 4 is also disclosed.

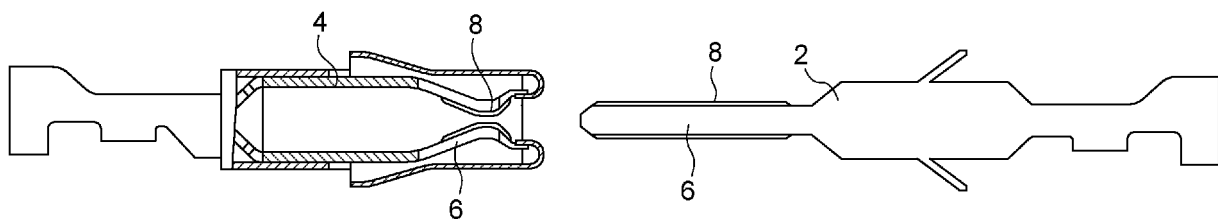


Figure 1

Description

Field of invention

[0001] The present invention relates to an electrical terminal and in particular, to an electrical terminal with a metal conductive layer comprising silver.

Background

[0002] Electrical connectors are typically formed from a base substrate material that is coated with a high electrical-conductivity layer to enable contacts to be mated with minimised contact resistance. Example electrical contacts include conductive pins insertable within back-plates and male and female push-fit contacts to couple electronic components and/or circuits. Typical electrically conducting plating materials include copper, gold, nickel, silver, tin and alloys thereof.

[0003] Silver as a contact plating provides high conductivity and ductility to allow the connectors to compress together when mated. This maximises the contact area and minimises contact resistance. Silver is also easy to solder. However, silver connectors, unlike other metals such as gold, tends to tarnish in air. Other plating materials may oxidise or can be susceptible to environmental degradation that may affect the conductivity, connection interface or integrity. Accordingly, in a process known as passivation, protective films or layers can be provided over the conducting layer to prevent corrosion and/or wear.

[0004] Difficulties exist in ensuring that the passivation process is consistent, and this results in variations in the protective properties of the passivation layer in the final product. Therefore, there is a desire for silver-containing terminals that do not require passivation. One known solution is to provide silver alloys (for example Ag-C, Ag-W or Ag-Cu) on a substrate. However, this too presents problems because the concentration of the element stoichiometry of the silver alloys is difficult to specify, produce and control. Thus, what is required is improved electrical connectors and contacts that do not require passivation and which are simpler to manufacture than the said known solutions.

[0005] It is known to use soft metals, such as indium or bismuth, in electrical connections, with the purpose of reducing the insertion forces and to reduce PCB damage during the connection process. Further, it is also known that silver may form an intermetallic phase with indium, gallium or tin.

Summary of the Invention

[0006] It is an objective of the present disclosure to provide an electrical connector having high electrical conductivity, low contact resistance as well as a resistance to environmental effects, wear and tarnishing. It is a further specific objective to provide a silver-based electrical

connector that has an improved or simplified manufacturing process. The electrical connector may be a male or female electrical terminal. It is a further specific objective to provide a process for manufacturing the electrical terminal.

[0007] According to a first aspect of the present disclosure there is provided an electrical terminal comprising a substrate and a metallic conductive layer provided on the substrate. The electrical terminal may be a male or female electrical terminal. The metallic conductive layer comprises either:

- a silver layer and an intermetallic phase of silver and one or a combination of indium or gallium, or;
- a silver layer and a bismuth layer, wherein the silver layer is located between the substrate and the bismuth layer.

[0008] The intermetallic phase may comprise elemental compounds, such as compounds of silver and indium or gallium or a mixture thereof. In addition, or alternatively the intermetallic phase may comprise a mixture of two or more elements, for example, silver and indium or gallium or mixture thereof.

[0009] The intermetallic phase or the bismuth layer protects the silver layer in the metallic conductive layer from environmental effects, wear and tarnishing. Further, the insertion forces required for the terminal are reduced due to the presence of the intermetallic phase. Additionally, a terminal is provided having a more stable insertion force. Such effects provide a terminal with enhanced longevity relative to existing terminals and that may be manufactured via convenient and raw material efficient processes.

[0010] In an embodiment, the intermetallic phase comprises tin. Preferably, the concentration of indium, gallium or tin in the intermetallic phase increases in a direction extending away from the substrate.

[0011] The intermetallic phase may include various intermetallic compounds; for example, AgIn_2 , Ag_2In , Ag_3Sn , Ag_2Ga , or Ag_3Ga_2 . Optionally, the intermetallic phase comprises indium and a wt% predominant intermetallic compound in the intermetallic phase is AgIn_2 ; or the intermetallic phase comprises gallium and a wt% predominant intermetallic compound in the intermetallic phase is Ag_3Ga_2 ; and/or Ag_2Ga ; or the intermetallic phase comprises tin and a wt% predominant intermetallic compound in the intermetallic phase is Ag_3Sn . The metallic conductive layer may comprise bismuth and silver and/or a silver-bismuth compound or alloy.

[0012] Ideally, the terminal further comprises a barrier layer between the substrate and the silver layer. The barrier layer prevents diffusion of the silver into the substrate. The barrier layer may comprise any one or a combination of the group comprising: nickel, copper or aluminium or alloys thereof. In an embodiment where the substrate comprises copper, the barrier layer may comprise nickel.

[0013] Optionally, the terminal further comprises a sil-

ver layer. Ideally, the silver layer comprises at least 50%, 60%, 70%, 80%, 90%, 95%, 97%, or 99% silver. Yet further optionally, the terminal comprises a layer of any one or a combination of the group comprising: indium, gallium, bismuth or tin comprising at least 50%, 60%, 70%, 80%, 90%, 95%, 97%, or 99% of any of indium, gallium, bismuth or tin. Alternatively, the terminal comprising both a silver layer comprising at least 50%, 60%, 70%, 80%, 90%, 95%, 97%, or 99% of silver and a layer of any one or a combination of the group comprising: indium, gallium, bismuth or tin comprising at least 50%, 60%, 70%, 80%, 90%, 95%, 97%, or 99% of any of indium, gallium, bismuth or tin.

[0014] Ideally, the layer of any one or a combination of the group comprising: indium, gallium or tin is disposed directly on the intermetallic phase. Further ideally, the intermetallic phase is disposed directly on the silver layer. Optionally, the silver layer is disposed directly on the barrier layer. Optionally the barrier layer is disposed directly on the substrate.

[0015] According to a second aspect of the invention there is provided a process for manufacturing the terminal of first aspect of the invention, the process comprising the steps of:

depositing silver directly or indirectly on a substrate to form a silver layer;

depositing any one or a combination of the group comprising: indium, gallium, bismuth or tin on the silver layer, to form a layer of any one or a combination of the group comprising: indium, gallium, bismuth or tin.

[0016] Ideally, the process comprises the step of tempering or storing the terminal to form an intermetallic phase comprising silver and any one or a combination of the group comprising: indium, gallium or tin.

[0017] The process may include a tempering step, storing step, or both a tempering and storing step. During tempering and storing, the thickness of the intermetallic phase increases, and consequently the thickness of the silver layer and the layer of any one or a combination of the group comprising: indium, gallium or tin decreases.

[0018] Ideally, the silver is deposited to a thickness of between 0.5 and 10 μm , 2 and 6 μm , or 4 and 5 μm .

[0019] Preferably, the indium, gallium, bismuth or tin or combination thereof is deposited to a thickness of between 0.1 and 5 μm , 0.3 and 2 μm , or 0.5 and 1 μm .

[0020] Ideally, the terminal is tempered by heating to a temperature within 50°C below the melting point of the indium, gallium, bismuth or tin. Preferably, the terminal is tempered by heating for between 5 seconds and 5 minutes.

[0021] Optionally, the terminal is stored for between 2 hours and 7 days after the indium, gallium, bismuth, tin or combination thereof is deposited.

[0022] Ideally, the process comprises initially forming a barrier layer on the substrate before depositing the sil-

ver and thereafter depositing the silver on the barrier layer. The barrier layer may be formed by depositing any one of or a combination of the group comprising: nickel, copper, aluminium or alloys thereof.

[0023] The barrier layer may be deposited to a thickness of between 0.1 and 10 μm , 0.5 and 3 μm , or 1 and 2 μm .

Brief description of drawings

[0024] A specific implementation of the present disclosure will now be described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 is a cross sectional view of a male and female electrical terminal, each terminal comprising a substrate and a metallic conductive layer provided on the substrate according to a specific implementation; and

Figure 2 is a flow diagram illustrating a process for manufacturing an electrical terminal according to a specific implementation of the present invention.

Detailed description of preferred embodiment of the disclosure

[0025] In Figure 1 there is shown a male electrical terminal 2 and a female electrical terminal 4 according to the invention. Each terminal 2, 4 comprises a metallic body, defining a substrate 6. In the embodiment shown, the substrate 6 is formed from copper alloy, but alternative metals may be used such as aluminium alloy. Each terminal 2, 4 further has a metallic conductive layer 8 provided on the substrate 6.

[0026] Referring now to Figure 2, the metallic conductive layer 8 has an intermetallic phase 10 of silver and indium. In other embodiments not shown, the intermetallic phase may be formed of silver and any other suitable chemical. Other suitable chemicals include the post-transition metals gallium or tin. The presence of indium protects the silver in the conductive layer 8 from environmental effects, wear and tarnishing. Further, as indium is softer than silver, the necessary insertion force for the terminals 2, 4 is reduced in the present invention when compared with terminals with pure silver conductive layers. Various modifications will be apparent to the skilled person. For example, the intermetallic phase may contain a plurality of elements other than silver, for example, a combination of any of indium, gallium or tin.

[0027] In the illustrated embodiment, the predominant wt% intermetallic compound in the intermetallic phase is AgIn_2 . The predominant compound can be controlled depending on the conditions of formation of the intermetallic phase. Other compounds may also be present, such as Ag_2In . In other embodiments, where bismuth or gallium is present, the predominant compound may be Ag_3Ga_2 respectively. Again, other compounds of silver-bismuth

or silver-gallium may be present.

[0028] The concentration of indium in the intermetallic phase 10 increases in a direction heading away from the substrate 6. In other words, the concentration of indium is lowest at a location close to the substrate 6 and highest at a location furthest away from the substrate 6. Further, in contrast, the concentration of silver in the intermetallic phase decreases in a direction heading away from the substrate 6. The concentration of silver therefore is greatest at a location close to the substrate 6 and lowest at a location furthest away from the substrate. In other embodiments where gallium or tin may be used in place of indium, or alongside indium, the concentration of these elements will again be lowest close to the substrate and highest further from the substrate.

[0029] The terminals 2, 4 each comprise a barrier layer 12 located between the substrate 6 and the intermetallic phase 10. The barrier layer 12 prevents diffusion of the silver into the substrate. In the illustrated embodiment, the barrier layer 12 is formed from nickel, but alternative materials may be used such as copper, aluminium, or alloys thereof. The thickness of the barrier layer 12 is preferably between 1 and 2 μm , but may alternatively be between 0.5 and 3 μm or 0.1 and 10 μm .

[0030] In the embodiment shown, the terminals 2, 4 further have a silver layer 14. In another embodiment, not shown, the metallic conductive layer 8 comprises a bismuth layer arranged on the silver layer. The silver layer 14 is located between the substrate 6 and intermetallic phase 10, or between the substrate and the bismuth layer. More specifically, the silver layer 14 is located between the barrier layer 12 and the intermetallic phase 10 or bismuth layer.

[0031] In the embodiment shown, the terminals 2, 4 further have an indium layer 16. The indium layer is the outermost layer of the metallic conductive layer 8. Thus, the intermetallic phase 10 is located between the indium layer 16 and silver layer 14, barrier layer 12 and substrate 6. The indium layer has a thickness of up to 5 μm . In other embodiments, the outermost layer may be a gallium, bismuth or tin layer, or combinations thereof, possibly also with indium.

[0032] The indium layer 16, which may also be formed from any of gallium, bismuth or tin or combination thereof, has a top surface 16a, and bottom surface 16b wherein the top surface 16a is at one side of the layer and the bottom surface 16b is at an opposing side. The intermetallic phase 10 further has a top surface 10a and a bottom surface 10b wherein the top surface 10a is at one side of the layer and the bottom surface 10b is at an opposing side. The bottom surface 16b of the indium layer 16 is in contact with the top surface 10a of the intermetallic phase 10. The top surface 16a of the indium layer is ideally exposed and represents the outermost surface of the conductive layer 8. The silver layer 14 further has a top surface 14a and a bottom surface 14b wherein the top surface 14a is at one side of the layer and the bottom surface 14b is at an opposing side. The bottom surface

10b of the intermetallic phase is in contact with the top surface 14a of the silver layer. The barrier layer 12 further has a top surface 12a and a bottom surface 12b wherein the top surface 12a is at one side of the layer and the bottom surface 12b is at an opposing side. The bottom surface 14b of the silver layer is in contact with the top surface 12a of the barrier layer. The substrate 6 has a top layer 6a. The top layer 6a of the substrate 6 is in contact with the bottom surface 12b of the barrier layer.

[0033] In use, the male electrical terminal 2 is inserted into the female electrical terminal 4. The metallic conductive layers 8 of each of the male and female electrical terminals 2, 4 then contact one another and electric current can then flow between the terminals 2, 4. Such terminals 2, 4 may be connected to electrical cables via crimping or ultrasonic welding. The electrical cables may be copper or aluminium cables. The terminals 2, 4 may be housed in a connector housing and joined to the electrical cables for connection with other related electrical equipment.

[0034] The terminals of the present invention can be formed by reel-to-reel plating. In reel-to-reel plating, strips of material or plated and then formed into the desired product. There are four known reel-to-reel plating techniques typically used to deposit metals on terminals: immersion plating, strip technique, brush plating, and spot technique. Immersion plating is typically used for depositing large quantities of metals, whereas spot technique offers higher selectivity to save metal quantity.

[0035] In reel-to-reel plating, rolled blank material or pre-stamped material is de-reeled and will be fed through multiple process including rinsing, plating and drying, before being rewound onto a new reel after having been plated.

[0036] The terminals of the present invention can be formed by an electro-plating process. In electro-plating, the substrate is placed into an electrolyte solution in an electrolysis bath. An anode is present in the electrolyte solution which comprises the desired coating material. The substrate is the cathode. The transfer of the material from the cathode is achieved by setting the electrolysis parameters such as bath temperature, pH, voltage, current, electrolyte concentration and rinsing steps. The skilled person will understand that many combinations of parameters exist that will achieve the adequate plating thickness and metal quality.

[0037] The terminals 2, 4 are formed according to the following method. Initially, the substrate 6 is provided. Next, the barrier layer 12 is formed by depositing nickel on the substrate 6 to a thickness of 1-2 μm . Alternatively, the nickel may be deposited to a thickness of 0.5-3 μm or 0.1-10 μm . Further alternatively, the barrier layer may be formed by depositing any one of or a combination of the group comprising: nickel, copper, aluminium or alloys thereof.

[0038] Next, silver 14 is deposited indirectly on the substrate 6 to form a silver layer. By "indirectly" we mean the silver is deposited on the barrier layer 12 which in turn is

deposited on the substrate 6. In other embodiments where no barrier layer is present, the silver 14 may be deposited directly on the substrate 6. The silver 14 is deposited to a thickness of between 4 and 5 μm . Alternatively, the silver 14 may be deposited to a thickness of between 0.5 and 10 μm or 2 and 6 μm .

[0039] Next, indium 16 is deposited on the silver layer 14 to form an indium layer 16. The indium 16 is deposited to a thickness of between 0.5 and 1 μm but may be deposited to thicknesses of between 0.1 and 5 μm , 0.3 and 2 μm . Alternatively, gallium, bismuth or tin may be deposited rather than indium, or combinations of any of indium, gallium, bismuth or tin.

[0040] Before processing to form the intermetallic phase, the bottom surface 16b of the indium layer 16 is in contact with the top surface 14a of the silver layer; the bottom surface 14b of the silver layer is in contact with the top surface 12a of the barrier layer, and; the top layer 6a of the substrate 6 is in contact with the bottom surface 12b of the barrier layer.

[0041] After the metals have been deposited and the layers formed, the terminals 2, 4 are then processed to form the intermetallic phase 10. The intermetallic phase 10 is formed by preferably tempering 16 and then storing 18 the terminals 2, 4. However, the intermetallic phase 10 may be also be formed by either a tempering step 16 or storage step 18 alone. During tempering or storing, the thickness of the intermetallic phase 10 increases, and consequently the thickness of the silver layer 14 and indium layer 16 decreases. After tempering or storing, the thickness of the indium, gallium or tin layers should be at least 50% of the initial thickness (i.e., the thickness before tempering). For example, the indium may be deposited to a thickness of between 0.3 and 2 μm . After tempering or storage, the indium layer should have a thickness of between 0.15 and 2 μm .

[0042] The tempering step 16 involves heating the terminal 2, 4 to a temperature within 50°C below the melting point of indium. Ideally, the terminal 2, 4 is heated to just below the melting point of indium, for example 140-150°C. Where metals other than indium are used, the heating temperature should be altered accordingly to below the melting point of the alternative metal. The heated temperature is maintained for 30 seconds, but shorter or longer periods may also be used and a range of between 5 seconds and 5 minutes may be suitable.

[0043] In the storage step 18, the terminal 2, 4 is simply stored, preferably at ambient temperature, for a period of time to allow the intermetallic phase 10 to form. Ideally, the terminal 2, 4 is stored for 1-3 days but shorter or longer time periods may also be acceptable, for example between 2 hours and 7 days.

[0044] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which the presently described subject matter pertains.

[0045] Where a range of values is provided, for example, concentration ranges, percentage ranges, or ratio

ranges, it is understood that each intervening value, to the tenth of the unit of the lower limit, unless the context clearly dictates otherwise, between the upper and lower limit of that range and any other stated or intervening value in that stated range, is encompassed within the described subject matter. The upper and lower limits of these smaller ranges may independently be included in the smaller ranges, and such embodiments are also encompassed within the described subject matter, subject to any specifically excluded limit in the stated range. Where the stated range includes one or both of the limits, ranges excluding either or both of those included limits are also included in the described subject matter.

[0046] It should be understood that the terms "a" and "an" as used above and elsewhere herein refer to "one or more" of the enumerated components. It will be clear to one of ordinary skill in the art that the use of the singular includes the plural unless specifically stated otherwise. Therefore, the terms "a," "an" and "at least one" are used interchangeably in this application.

[0047] Unless otherwise indicated, all numbers expressing quantities of ingredients, properties such as size, weight, reaction conditions and so forth used in the specification and claims are to be understood as being modified in all instances by the term "about". Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained by the present subject matter. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques.

[0048] Throughout the application, descriptions of various embodiments use "comprising" language; however, it will be understood by one of skill in the art, that in some instances, an embodiment can alternatively be described using the language "consisting essentially of" or "consisting of."

Claims

1. An electrical terminal comprising a substrate and a metallic conductive layer provided on the substrate **characterised in that** the metallic conductive layer comprises either:

a silver layer and an intermetallic phase of silver and one or a combination of indium or gallium, or;
a silver layer and a bismuth layer, wherein the silver layer is located between the substrate and the bismuth layer.

2. The terminal as claimed in claim 1, wherein the in-

- intermetallic phase optionally comprises tin, and wherein the concentration of indium, gallium or tin in the intermetallic phase increases in a direction extending away from the substrate.
3. The terminal as claimed in claim 1 or claim 2, wherein:
 - the intermetallic phase comprises indium and a wt% predominant intermetallic compound in the intermetallic phase is AgIn_2 ;
 - the intermetallic phase comprises gallium and a wt% predominant intermetallic compound in the intermetallic phase is Ag_3Ga_2 ; and/or Ag_2Ga ; or
 - the intermetallic phase comprises tin and a wt% predominant intermetallic compound in the intermetallic phase is Ag_3Sn ;
 4. The terminal as claimed in any preceding claim further comprising: a barrier layer between the substrate and the silver layer, optionally wherein the barrier layer comprises nickel.
 5. The terminal as claimed in any preceding claim further comprising a layer of any one or a combination of the group comprising: indium, gallium, bismuth or tin.
 6. The terminal as claimed in claim 5 wherein the layer of any one or a combination of the group comprising: indium, gallium, bismuth or tin is disposed directly on the intermetallic phase, and wherein the intermetallic phase is disposed directly on the silver layer, and optionally wherein the silver layer is disposed directly on the barrier layer, and optionally wherein the barrier layer is disposed directly on the substrate.
 7. A process for manufacturing the terminal of claim 1, the process comprising the steps of:
 - depositing silver directly or indirectly on a substrate to form a silver layer;
 - depositing any one or a combination of the group comprising: indium, gallium, bismuth or tin on the silver layer, to form a layer of any one or a combination of the group comprising: indium, gallium, bismuth or tin.
 8. The process of claim 8 comprising the step of tempering and/or storing the terminal to form an intermetallic phase comprising silver and any one or a combination of the group comprising: indium, gallium or tin.
 9. The process of claim 7 or claim 8 wherein the silver is deposited to a thickness of between 0.5 and 10 μm .
 10. The process of any one of claims 7 to 9 wherein the indium, gallium, bismuth or tin or combination thereof is deposited to a thickness of between 0.1 and 5 μm .
 11. The process of any one of claims 7 to 10 wherein the terminal is tempered by heating to a temperature within a range 50°C below the melting point of the indium, gallium, bismuth or tin.
 12. The process of claim 11 wherein the terminal is tempered by heating for between 5 seconds and 5 minutes.
 13. The process of any one of claims 7 to 12 wherein the terminal is stored for between 2 hours and 7 days after the indium, gallium, bismuth, tin or combination thereof is deposited.
 14. The process of any one of claims 7 to 13 comprising initially forming a barrier layer on the substrate before depositing the silver and thereafter depositing the silver on the barrier layer.
 15. The process of claim 14 wherein the barrier layer is formed by depositing any one of or a combination of the group comprising: nickel, copper, aluminium or alloys thereof, and optionally wherein the barrier layer is deposited to a thickness of between 0.1 and 10 μm .

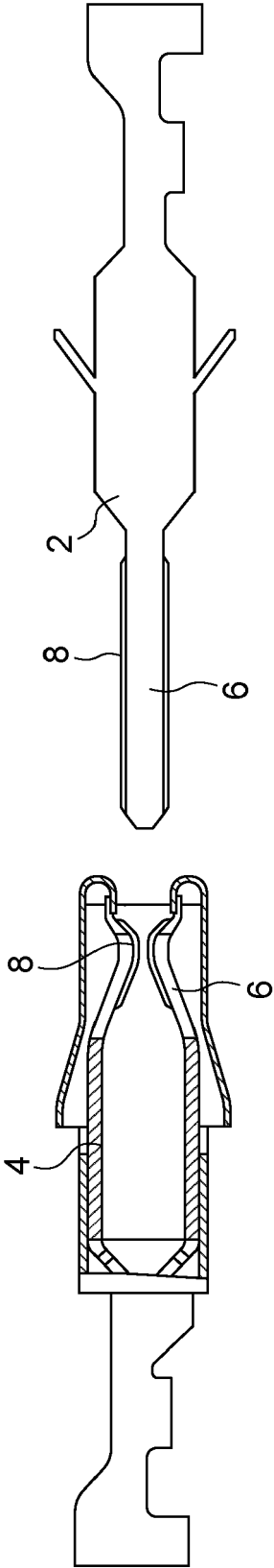


Figure 1

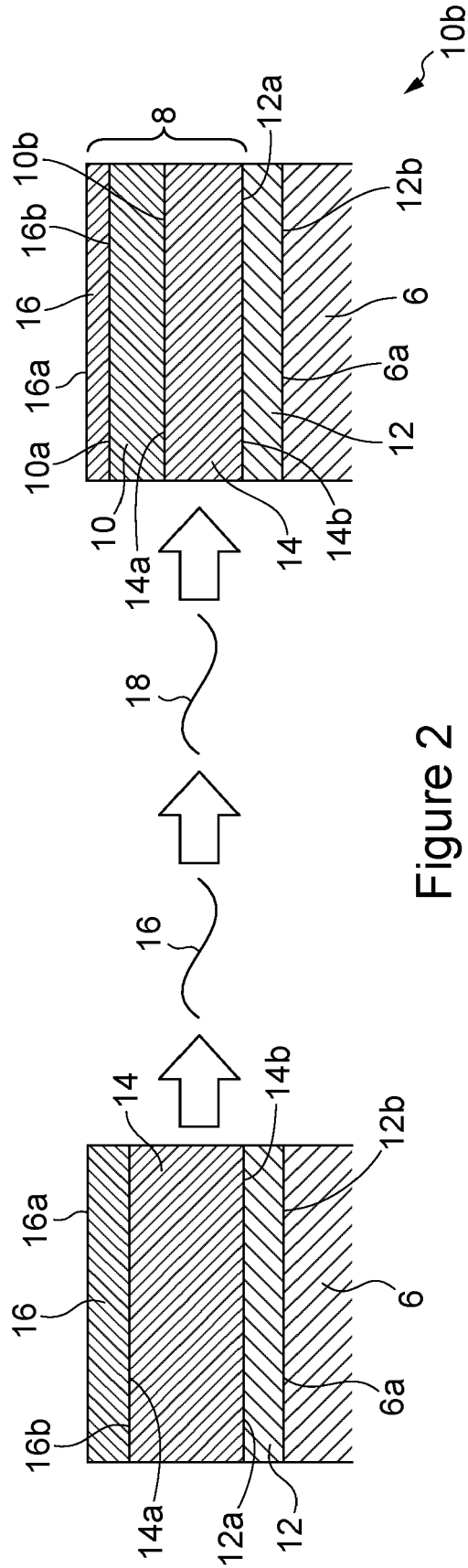


Figure 2



EUROPEAN SEARCH REPORT

Application Number

EP 22 21 3244

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EPO FORM 1503 03.82 (P04C01)

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	US 2013/224515 A1 (FOYET ADOLPHE [CH] ET AL) 29 August 2013 (2013-08-29) * abstract * * example 4 * * paragraphs [0008] - [0014] * -----	1-9, 11-14	INV. C25D5/48 C25D5/00 C25D7/00 C25D5/12 C25D5/50
X	US 9 576 693 B2 (SHIBUYA YOSHITAKA [JP]; FUKAMACHI KAZUHIKO [JP] ET AL.) 21 February 2017 (2017-02-21) * abstract * * example 7 * * table 8 * * column 1, lines 13-26 * -----	1-8, 13, 14	H01R13/03 C25D5/10 ADD. H01R13/02 H01R13/11
X	US 10 530 084 B2 (JX NIPPON MINING & METALS CORP [JP]) 7 January 2020 (2020-01-07) * abstract * * table 1 * * column 1, lines 16-30 * * column 9, lines 20-57 * -----	1-10, 13-15	
X	US 2021/158990 A1 (KUBOTA KENJI [JP] ET AL) 27 May 2021 (2021-05-27) * abstract * * examples * * claim 1 * * table 1 * * paragraphs [0072], [0075] * -----	1, 3, 4, 7-11, 13-15	TECHNICAL FIELDS SEARCHED (IPC) C25D H01R
X	JP 2004 238689 A (KYOWA ELECTRIC WIRE) 26 August 2004 (2004-08-26) * abstract * * figure 1 * * claims 1, 4 * * example 2 * -----	1, 2, 4-11, 13, 14	
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 22 August 2023	Examiner Lange, Ronny
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			



EUROPEAN SEARCH REPORT

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EPO FORM 1503 03.82 (P04C01)

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	US 2019/234994 A1 (ENDO SATORU [JP]) 1 August 2019 (2019-08-01) * abstract * * examples 1-16 * * tables 1, 2 * * claim 10 * -----	1-3, 7-10, 13-15	
			TECHNICAL FIELDS SEARCHED (IPC)
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 22 August 2023	Examiner Lange, Ronny
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	



Application Number

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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).



LACK OF UNITY OF INVENTION **SHEET B**

Application Number

EP 22 21 3244

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-15 (partially)

Inventive concept I regards an electrical terminal comprising a substrate and a metallic conductive layer provided on the substrate, wherein the metallic conductive layer comprises:

a silver layer and an intermetallic phase of silver and indium.

Inventive concept I also concerns the respective process for manufacturing said terminal.

2. claims: 1-15 (partially)

Inventive concept II regards an electrical terminal comprising a substrate and a metallic conductive layer provided on the substrate, wherein the metallic conductive layer comprises:

a silver layer and an intermetallic phase of silver and gallium.

Inventive concept II also concerns the respective process for manufacturing said terminal.

3. claims: 1-7, 9-15 (all partially)

Inventive concept III regards an electrical terminal comprising a substrate and a metallic conductive layer provided on the substrate, wherein the metallic conductive layer comprises: a silver layer and a bismuth layer, wherein the silver layer is located between the substrate and the bismuth layer.

Inventive concept III also concerns the respective process for manufacturing said terminal.

4. claims: 1-15 (partially)

Inventive concept IV regards an electrical terminal comprising a substrate and a metallic conductive layer provided on the substrate, wherein the metallic conductive layer comprises a silver layer and a tin layer, wherein the silver layer is located between the substrate and the tin layer.

Inventive concept IV also concerns the respective process for manufacturing said terminal.

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