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(54) **Electrical connector or electrical terminal, and metal sheet or strip for the manufacture thereof**

(57) The invention relates to an electrical connector or electrical terminal comprising an electrically conductive metallic element.

The invention is characterized in that the metallic element has been manufactured from a copper clad steel sheet or strip, wherein the steel is a stainless steel or a high strength steel and the copper clad layer has a

purity of 92,0 % Cu or higher, preferably 99,0 % Cu or higher.

The invention also relates to a metal sheet or strip for the manufacture of such metallic elements for electrical connectors or electrical terminals.

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Description

[0001] The invention relates to an electrical connector or electrical terminal comprising an electrically conductive metallic element, wherein the metallic element comprises a steel backing component and a metal component having a high electrical conductivity. The invention also relates to a metal sheet or strip for the manufacture of such metallic elements for electrical connectors or electrical terminals.

[0002] Electrical connectors (and electrical terminals) are known in principle in two types: one-component connectors and two-component connectors. One-component connectors combine the electrically conductive element and backing element in one metal component, which is usually a copper alloy. Depending on the properties the connector should have, copper-beryllium, CuNi9Sn2, CuFe2P, CuNiSi, CuSn6, CuNi12Zn24 or another copper alloy is used. The higher the amount of alloying elements in the copper alloy, the lower the electrical conductivity will be, but the higher the mechanical strength and spring back property of the component will be. The best alloying element is beryllium, the copper-beryllium alloy combining a reasonable conductivity with excellent mechanical properties, but beryllium is regarded as carcinogenic and therefore the use of beryllium is banned.

[0003] To overcome the drawbacks of the one-component connector, two-component connectors have been invented, consisting of two separate components: an outside clamp housing and an inside copper connector part. The mechanical strength and the spring back property are usually provided by a high strength stainless spring steel (like e.g. 1.4310) housing and the electrical conductivity is provided by a pure copper component in the housing. However, the drawback of this known two-component connector is that the manufacturing costs of such a two-component connector are high due to the pressing of two components and the low speed of such pressing, the expensive design of such a connector, et cetera.

[0004] It is an object of the invention to provide electrical connectors and terminals that will be more simple in design and production than the known electrical connectors and terminals.

[0005] It is another object of the invention to provide electrical connectors and terminals that are cheaper to produce than the known electrical connectors and terminals.

[0006] It is yet another object of the invention to provide electrical connectors and terminals which are environmentally safe to use.

[0007] According to a first aspect of the invention one or more of these objects are reached with an electrical connector or electrical terminal comprising an electrically conductive metallic element, wherein the metallic element has been manufactured from a copper clad steel sheet or strip, wherein the steel is a stainless steel or a

high strength steel and the copper clad layer has a purity of 92,0 % Cu or higher.

[0008] This connector or terminal thus has a metallic element that does not consist of two separate components, but of one component made from a copper clad steel sheet or strip. Such a metallic element, which forms the heart of an electrical connector or terminal, is far easier to produce and handle than a metallic element consisting of two separate parts. The producer of the connector or terminal now only has to cut the metallic element from the clad sheet or strip and form it into the desired shape, whereas for the known connectors the producer has to cut two components from two sheets or strips, has to form both components and had to combine those components as well. Though the clad sheet or strip could be more expensive than the two separate sheets or strips, the production costs for producing connectors or terminals from one sheet or strip are far lower.

[0009] With this electrical connector or terminal according to the invention both the required electrical, mechanical and corrosion protection properties and the one-component manufacturing process are attained.

[0010] The copper clad layer has a purity of 92,0 % Cu or higher in view of the desired electrical conductivity: more than 8 m/Ohm x mm², preferably at least 15 m/Ohm x mm² which is equivalent to 26 % IACS (100 % IACS is equivalent to the conductivity of pure copper = 58 m/Ohm x mm²). IACS is the abbreviation of International Annealed Copper Standard.

[0011] Preferably the copper clad layer has a purity of 99,0 % Cu or higher. Such a high purity provides an electrical conductivity that is still higher, being equivalent to at least 52 m/Ohm x mm² (90 % IACS).

[0012] More preferably, the copper has a purity of 99,5 % Cu or higher, being equivalent to at least at least 55 m/Ohm x mm² (95 % IACS), still more preferably 99,9 % Cu or higher, being equivalent to at least 58 m/Ohm x mm² (100 % IACS). These purities are for special purposes.

[0013] If the copper clad layer has a purity of 92,0 % Cu or higher, the copper clad layer comprises nickel, tin, zinc and/or iron. These elements are environment friendly.

[0014] In this case the copper clad layer preferably consists of CuSn2, Cu Fe2P, CuZn8, CuNi3Si, CuAg0,1Cr1Zr or CuCo2. These are known copper alloys that can be clad.

[0015] Preferably, the copper layer clad onto the steel sheet or strip is Cu-HCP, Cu-PHC, Cu-DHP or Cu-OF copper strip. These are known international standards for copper strip. See standard EN 13599 and EN 1652.

[0016] According to a preferred embodiment the copper clad layer is present on both sides of the steel sheet or strip. This is often preferred over a single-sided clad layer in view of the electrical connection.

[0017] According to a preferred embodiment the stainless steel is ferritic stainless steel. Ferritic stainless steel has a good corrosion resistance and provides rea-

sonable mechanical strength properties at a reasonable price level.

[0018] According to another preferred embodiment the stainless steel is austenitic stainless steel. This type of steel is often more expensive, but can be more suitable in certain cases.

[0019] Preferably the stainless steel is type 301 stainless steel (ASTM). This is a commercially available stainless steel type, 1.4310 (EN 10088-2). This steel type shows excellent mechanical and spring properties, is extremely corrosion resistant, but shows poor electrical conductivity (approximately 5 % IACS). It is the preferred stainless steel type for connectors at a higher price level.

[0020] According to still another preferred embodiment the high strength steel is a carbon steel, for instance C30 or C60. This steel type (all grades in EN 10132) is cheaper and can be used in many applications.

[0021] Preferably the high strength steel is a high strength low alloy (HSLA) steel, for instance ZE 800 (EN 10268) or a dual phase (DP) steel, for instance S690 (EN 10149-2). These are commercially available steel types having good mechanical properties, but the corrosion protection of HSLA and DP steel is lower than the corrosion protection of stainless steel. An electrical connector or terminal according to the invention using HSLA or DP steel will have good electrical properties and result in major cost savings, and encapsulation in plastic or installation in less corrosive environments will overcome the disadvantage of the lower corrosion resistance.

[0022] According to a preferred embodiment the metallic element has a gauge of 0.1 to 0.5 mm, preferably 0.15 to 0.3 mm. This gauge is preferred for producing connectors or terminals.

[0023] According to a preferred embodiment the copper clad layer has been applied on one side of the steel sheet or strip, the copper clad layer having a thickness of 1 to 70 % of the total thickness of the steel sheet or strip, preferably a thickness of 5 to 40 % of the thickness of the steel sheet or strip, more preferably a thickness of 10 to 30 % of the thickness of the steel sheet or strip. These thicknesses depend on the use of the connector or terminal.

[0024] According to another preferred embodiment, the copper clad layer has been applied on both sides of the steel sheet or strip, the copper clad layers together having a thickness of 2 to 70 % of the total thickness of the copper clad steel sheet or strip, preferably the copper clad layers together having a thickness of 10 to 50 % of the total thickness of the steel sheet or strip, more preferably together having a thickness of 20 to 30 % of the total thickness of the steel sheet or strip. The metallic element will need a copper clad layer on both sides of the steel layer when the connection to be made by the connector or terminal needs a good electrical conductivity on both sides of the metallic element. The copper

clad layers could for example each have a thickness of 10 % of the total thickness of the sheet or strip.

[0025] It is also possible to use a copper clad steel sheet or strip of which the copper clad layer on one side of the steel sheet or strip has a thickness that is different from the thickness of the copper clad layer on the other side of the steel sheet or strip. This can be useful when the requirements of conductivity for one side of the metallic element differ from those for the other side. For instance, the copper clad layer on one side has a thickness of 10 to 50 % and the copper clad layer on the other side has a thickness of 0 to 5 % of the total thickness of the sheet or strip.

[0026] Preferably the metallic element is coated with a tin or tin alloy layer on both sides, the tin layer preferably having a thickness of 1 to 10 µm on each side, preferably a thickness of 2 to 4 µm. A tin or tin alloy layer is applied for lubrication, contact resistance and corrosion protection.

[0027] According to a second aspect of the invention there is provided a clad metal sheet or strip for the manufacture of metallic elements for electrical connectors or electrical terminals according to the first aspect of the invention, wherein the clad metal sheet or strip is a copper clad sheet or strip comprising a steel core layer, wherein the steel is a stainless steel or a high strength steel, and a copper clad layer, the copper having a purity of 92,0 % Cu or higher, on at least one side of the steel core layer.

[0028] The sheet or strip according to the second aspect of the invention can be directly use for manufacturing the electrical connectors and electrical terminals according to the first aspect of the invention, and as such replaces the two sheets or strips (a steel strip and a copper or copper alloy strip) that until now have to be used for the manufacture of such connectors or terminals.

[0029] According to a preferred embodiment, the steel sheet or strip has a thickness of 0.5 to 3.0 mm, preferably 0.7 to 1.3 mm. On this steel sheet or strip a copper strip is clad and rolled to a desired thickness for manufacturing the electrical connectors or terminals according to the first aspect of the invention.

[0030] According to a preferred embodiment the clad metal sheet or strip has been annealed and rolled to a thickness of 0.1 to 0.5 mm, preferably to a thickness of 0.15 to 0.3 mm. These thicknesses are commonly used for manufacturing electrical connectors and terminals; in most cases a thickness of 0.15 to 0.3 mm is used.

[0031] Preferably a tin or tin alloy layer is present on both sides of the clad metal sheet or strip, each tin or tin alloy layer preferably having a thickness of 1 to 10 µm, more preferably 2 to 4 µm. The tin or tin alloy layer has been provided on the clad metal sheet or strip to provide a better lubrication, contact resistance and corrosion resistance of the electrical connectors or terminal manufactured from the sheet or strip.

[0032] The invention will be elucidated with reference to the following example.

[0033] A copper clad steel strip is manufactured starting from a steel strip having a width of 500 mm and a thickness of 1,0 mm, and a copper strip Cu-HCP having a purity of 99,5 %, having a width of 540 mm and a thickness of 0,1 mm. The sides that have to contact each other are subjected to a pretreatment with a chemical alkaline cleaner and a mechanical brushing. The two strips are clad under the usual condition with a reduction of 25 to 60 %.

[0034] After cladding the strip is cold rolled and annealed under protective gas atmosphere (nitrogen/hydrogen or pure hydrogen, for instance) and recrystallised at approximately 800° C for high strength steel (for instance C30, Z800 or S690) or at approximately 900 to 1000° C for stainless steel type 301 (1.4310 EN 10088-2).

[0035] A final cold rolling step is applied with a reduction of at least 5 %, to provide a final thickness of 0,25 mm. The width of the strip remains 500 mm.

[0036] Optionally a coating with a thin tin or tin alloy layer (1 to 10 µm) is provided, for instance by hot dipping or electrolytic coating.

[0037] Usually, the clad strip is slit into strips of smaller width before it is packed and sent to the manufacturer of electrical connectors or electrical terminals. There, the clad strips are (partially) cut into the desired form and formed into the desired shape as metallic element for the electrical connector or terminal.

Claims

1. Electrical connector or electrical terminal comprising an electrically conductive metallic element, **characterized in that** the metallic element has been manufactured from a copper clad steel sheet or strip, wherein the steel is a stainless steel or a high strength steel and the copper clad layer has a purity of 92,0 % Cu or higher.
2. Electrical connector or electrical terminal according to claim 1, wherein the copper clad layer has a purity of 99,0 % Cu or higher.
3. Electrical connector or electrical terminal according to claim 2, wherein the copper clad layer has a purity of 99,5 % Cu or higher, preferably 99,9 % Cu or higher.
4. Electrical connector according to claim 1, wherein the copper clad layer comprises nickel, tin, zinc and/or iron.
5. Electrical connector according to claim 4, wherein the copper clad layer consists of CuSn2, Cu Fe2P, CuZn8, CuNi3Si, CuAg0,1Cr1Zr or CuCo2.
6. Electrical connector or electrical terminal according

to claim 2 or 3, wherein the copper clad layer clad onto the steel sheet or strip is Cu-HCP, Cu-PHC, Cu-DHP or Cu-OF copper strip.

7. Electrical connector or electrical terminal according to any one of the preceding claims, wherein the copper clad layer is present on both sides of the steel sheet or strip.
8. Electrical connector or electrical terminal according to any one of the preceding claims, wherein the stainless steel is ferritic stainless steel.
9. Electrical connector or electrical terminal according to any one of the claims 1 - 7, wherein the stainless steel is austenitic stainless steel.
10. Electrical connector or electrical terminal according to claim 8 or 9, wherein the stainless steel is type 301 stainless steel.
11. Electrical connector or electrical terminal according to any one of the claims 1 - 7, wherein the high strength steel is a carbon steel, for instance C30 or C60.
12. Electrical connector or electrical terminal according to claim 11, wherein the high strength steel is a high strength low alloy (HSLA) steel, for instance ZE 800, or wherein the high strength steel is a dual phase steel, for instance S690.
13. Electrical connector or electrical terminal according to any one of the preceding claims, wherein the metallic element has a gauge of 0.1 to 0.5 mm, preferably 0.15 to 0.3 mm.
14. Electrical connector or electrical terminal according to any one of the claims 1 - 13, wherein the copper clad layer has been applied on one side of the steel sheet or strip, the copper clad layer having a thickness of 1 to 70 % of the total thickness of the copper clad steel sheet or strip, preferably a thickness of 5 to 40 % of the total thickness of the steel sheet or strip, more preferably a thickness of 10 to 30 % of the total thickness of the steel sheet or strip.
15. Electrical connector or electrical terminal according to any one of the claims 1 - 13, wherein the copper clad layer has been applied on both sides of the steel sheet or strip, the copper clad layers together having a thickness of 2 to 70 % of the total thickness of the copper clad steel sheet or strip, preferably the copper clad layers together having a thickness of 10 to 50 % of the total thickness of the steel sheet or strip, more preferably together having a thickness of 20 to 30 % of the total thickness of the steel sheet or strip.

16. Electrical connector or electrical terminal according to claim 16, wherein the copper clad layer on one side of the steel sheet or strip has a thickness that is different from the thickness of the copper clad layer on the other side of the steel sheet or strip. 5
17. Electrical connector or electrical terminal according to any one of the preceding claims, wherein the metallic element is coated with a tin or tin alloy layer on both sides, the tin or tin alloy layer preferably having a thickness of 1 to 10 μm on each side, preferably a thickness of 2 to 4 μm . 10
18. Clad metal sheet or strip for the manufacture of metallic elements for electrical connectors or electrical terminals according to any one of claims 1 - 17, **characterized in that** the clad metal sheet or strip is a copper clad sheet or strip comprising a steel core layer, wherein the steel is a stainless steel or a high strength steel, and a copper clad layer, the copper having a purity of 92,0 % Cu or higher, on at least one side of the steel core layer. 15 20
19. Clad metal sheet or strip according to claim 18, wherein the steel sheet or strip has a thickness of 0.5 to 3.0 mm, preferably 0.7 to 1.3 mm. 25
20. Clad metal sheet or strip according to claim 18, wherein the clad metal sheet or strip has been annealed and rolled to a thickness of 0.1 to 0.5 mm, preferably to a thickness of 0.15 to 0.3 mm. 30
21. Clad metal sheet or strip according to claim 20, wherein a tin or tin alloy layer is present on both sides of the clad metal sheet or strip, each tin or tin alloy layer preferably having a thickness of 1 to 10 μm , more preferably 2 to 4 μm . 35

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EUROPEAN SEARCH REPORT

Application Number
EP 03 07 8003

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Place of search THE HAGUE		Date of completion of the search 30 January 2004	Examiner Salojärvi, K
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