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(54) **COPPER COMPOUND MATERIAL**

(57) The present invention relates to copper compound material as contact (12, 18) material for vacuum interrupters. The copper material comprises materials of the group comprising tungsten carbide copper and/or chromium carbide copper and/or chromium copper and/or copper. Further, the at least one compound element is selected from the groups comprising lanthanum

hexaboride and/or lanthanum oxide and/or gadolinium oxide and/or gallium oxide and/or cerium dioxide. Additionally, or alternatively thereto the compound material comprises graphite and/or graphene and/or fullerene and/or diamond and/or carbo nanotubes and/or multilayer graphene.

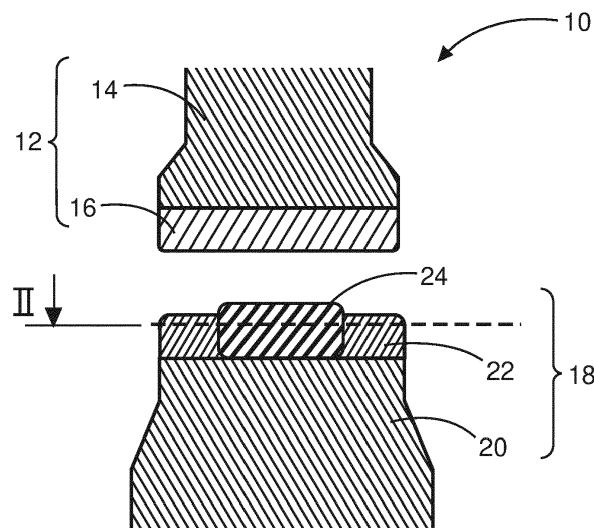


Figure 1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a copper compound material and a vacuum interrupter comprising such a copper compound material.

BACKGROUND OF THE INVENTION

[0002] There are basically several types of devices which are used for current interruption, i.e. contactors, load break switch and circuit breakers for low-, medium and high voltage. All these devices are using a vacuum interrupter to interrupt the load or short circuit current. Vacuum interrupters in contactors have a lower interrupting rating and are constructed to operate more frequently than the ones used in circuit breakers.

[0003] During the interruption process of load currents, the current in vacuum interrupters tends to prematurely interrupts before reaching the natural current zero of the AC frequency waveforms. This sudden interruption in the load current is defined as current chopping and depending on its magnitude and frequency, it can cause serious insulation degradation over the lifetime of a connected device and is thus undesired.

[0004] The vacuum interrupter has typically one fixed and one moveable contact. Depending on the application (contactor or circuit breaker), the material of contacts of vacuum interrupter might be using different metal composition, that allows them to exhibit lowest chopping current. The selection of contact materials influences the magnitude of the chopping current. However, said material must fulfill also other requirements like short circuit interrupting capability, ohmic resistance and resistance to wear (less erosion while load interruption) and the tendency to micro-weld.

[0005] Prior art DE 10 2014 209 762 A1 discloses a method of manufacturing a contact body for an electrical switching contact for a vacuum interrupter or an air-insulated switch for the medium and/or high voltage range. Further, a contact body for such a device is disclosed. The contact body is made of a composite material, wherein the composite material comprises CuCr, WCu, WCCu, WAg or WCAg.

SUMMARY OF THE INVENTION

[0006] The problem to be solved by the present invention is to provide a contact material for vacuum interrupters having a low chopping current and a vacuum interrupter comprising a contact with such a material.

[0007] The problem is solved by a copper compound material as contact material for vacuum interrupters having the features of claim 1. Further, a vacuum interrupter is proposed comprising a contact with such a material having the features of claim 7. Preferred embodiments of the invention are specified in the dependent claims.

[0008] According to the invention, a copper compound material as contact material for vacuum interrupters is proposed. The copper material comprises materials of the group a.) comprising tungsten carbide copper and/or chromium carbide copper and/or chromium copper and/or copper. The at least one compound element thereby is selected from the group b.) comprising lanthanum hexaboride and/or lanthanum oxide and/or gadolinium oxide and/or gallium oxide and/or cerium dioxide. Additionally, or alternatively thereto, the compound material comprises graphite and/or graphene and/or fullerene and/or diamond and/or carbon nanotubes and/or multilayer graphene from group c.).

[0009] The carbon-based materials have the property of a low chopping current. By adding the materials of group b.) in addition, comprising the materials lanthanum hexaboride, lanthanum oxide, gadolinium oxide, gallium oxide, cerium dioxide, the chopping current further can be reduced. These material combinations therefore have the properties to remarkably reduce the chopping current, while the requirements for short circuit interrupting capability, ohmic resistance, resistance to wear and tendency to micro-weld are fulfilled.

[0010] In a preferred embodiment of the invention, the tungsten carbide copper material of group a.) comprises 5-80 wt.-% of tungsten carbide. The tungsten carbide copper material with such an amount is specially merely mixed with one or more materials of group b.) comprising the materials lanthanum hexaboride, lanthanum oxide, gadolinium oxide, gallium oxide, cerium dioxide. Especially preferred the tungsten carbide copper material comprises 10-50 wt.-% of tungsten carbide is specially mixed with one or more carbon materials of group c.) comprising graphite, graphene, fullerene, diamond, carbon nanotubes, multilayer graphene. These material combinations have the properties to remarkably reduce the chopping current while the requirements for short circuit interrupting capability, ohmic resistance and resistance to wear are fulfilled.

[0011] In a further preferred embodiment, the chromium carbide copper material of group a.) is mixed in the range of 2-65 wt.-% of chromium carbide. Especially preferred, the chromium carbide material is mixed in the range of 2-40 wt.-%. The main advantage of the range between 2-40 wt.-% results out from getting erosion resistance on the one hand side and the foreseen reduction of chopping current on the other side by keeping the resistance and mechanical properties of the bulk contact material the same as today.

[0012] Advantageously, the chromium copper material of group a.) is mixed in the range of 2-65 wt.-% of chromium. The advantage is that this keeps the material properties the same as today and allow during the warm treatment process (sintering/infiltrating) the chemical reaction on the outer surface of each single particle with the preferable carbon material getting a graduated particle from chromium carbide from the surface to chromium at the inner area of each particle.

[0013] Preferably, the graphite, graphene, fullerene, diamond, carbo nanotubes, multilayer graphene material of group c.) is mixed up to 8 wt.-% of the selected forms of carbon. Especially preferred the graphite, graphene, fullerene, diamond is mixed up to 6 wt.-% of the selected forms of carbon. With an amount of carbon with up to 6 wt.-% the mechanical properties of the compound material are still sufficient for making and breaking operation in vacuum devices under mechanical no load and mechanical / current load operation.

[0014] In a further advantageous development, the compound materials of group b.) are mixed up to 5 wt.-%. By the selection of a small amount of these metal oxides an electron emission from contact material is achieved in order to keep the needed current flow around current zero crossing stable and to lower the chopping current. Furthermore, the mechanical properties are kept and even improved due to the presence of fine dispersoids inside the contact material. Mainly the dispersoid(s) must be added by mechanical alloying to achieve the hardening effect of final contact material.

[0015] Further, the problem is solved by a vacuum interrupter comprising one fixed contact and one movable contact, wherein at least one contact comprises the copper compound according to the present invention. With such a vacuum interrupter, the advantages mentioned above can be achieved.

[0016] In a preferred embodiment, the contacts are fully made of the copper compound. Such contacts have a low chopping current. Further, all other requirements necessary for contacts for vacuum interrupters are also fulfilled.

[0017] A preferred embodiment specifies that a surface of the contacts be made of the copper compound. The contacts thereby are made of a basic material such as preferably copper, and merely the surface of the contacts comprising the copper compound material. The basic material usually is less expensive than the copper compound material. Accordingly, the contacts can be manufactured much more economically. Preferably, the surface comprises a layer up to 6mm thickness of the copper compound.

[0018] In a further example, at least one of the contact surfaces is produced with a contact pin having a height exceeding a height of a ring contact plate. During normal operation of vacuum interrupter, when the contacts are closed, the nominal current is flowing through the contact pin and is thus not affected by the material of ring contact plate which might have higher resistance. It must have also higher resistance to micro-welding at the same time. For low current interruption, the arc will move towards the center of the contact as the arc voltage of the contact pin of the inner area is lower than the arc voltage of the ring contact plate material of the outer area. When the current approaches the zero-crossing, the low chopping current of material will apply.

[0019] For high currents interruption, like short-circuit currents, the arc will be driven away from the center by

the plasma pressure, the diffusion from the inner side of the arc to blow out of its current and the occurring Lorentz force. So, the high short circuit interruption capability of ring contact plate material will be applied.

[0020] In an example of the invention, the compound material for contact pin is different from compound material of the rest of the ring contact plate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The subject matter of the Invention will be explained in more details in the following description illustrated in the drawings, in which:

Figure 1 Embodiment of a contact arrangement of a vacuum interrupter, and

Figure 2 Cross-sectional view of the ring contact plate with the contact pin.

[0022] Figure 1 shows an embodiment of a contact arrangement 10 of a vacuum interrupter is shown. The contact arrangement 10 comprises a moveable contact 12 with a movable main contact body 14 on which a contact surface 16 is provided. A material of the contact surface 16 differs to the material of the movable main contact body 14. The contact surface 16 is provided as a circular contact plate, which is arranged on an axial end of the movable main contact body 14.

[0023] The contact arrangement 10 further comprises a fixed contact 18. The fixed contact 18 comprises a fixed main contact body 20 and a ring contact plate 22 with a contact pin 24. Ring contact plate 22 and contact pin 24 are made of different materials. The ring contact plate 22 with the contact pin 24 are arranged on an axial end of the fixed main contact body 20, to connect with the contact surface 16 of the movable contact 12. In the shown embodiment the contact pin 24 axially extends over the ring contact plate 22. During normal operation of the vacuum interrupter, when the contacts 12, 18 are closed, the nominal current is flowing through the contact pin 24 and is thus not affected by the material of the ring contact plate 22 which might have higher electrical resistance. It must have also a higher resistance to micro-welding at the same time. For low current interruption, the arc will move towards the centre of the contact as the arc voltage of the contact pin 24 of the inner area is lower than the arc voltage of the ring contact plate material 22 of the outer area. So, when the current approaches the zero-crossing, the low chopping current of the material will apply. For high currents interruption, like short-circuit currents, the arc will be driven away from the centre by the plasma pressure, the diffusion from the inner side of the arc to blow out of its current and the occurring Lorentz force. So, the high short circuit interruption capability of ring contact plate 22 material will be applied.

[0024] Figure 2 shows a cross-sectional view of the ring contact plate 22 with the contact pin 24. In this figure

it is shown that the contact pin 24 is provided in a centre, whereas the ring contact plate 22 is arranged concentrically to the contact pin 24.

[0025] In a real application, both fixed and moveable contacts 12, 16 could be also of the same construction, i.e. both having just a contact surface layer or both having that layer composed of a ring contact plate 22 with contact pin 24.

List of reference numbers

[0026]

- 10 contact arrangement
- 12 moveable contact
- 14 movable main contact body
- 16 contact surface
- 18 fixed contact
- 20 fixed main contact body
- 22 Ring contact plate
- 24 contact pin

Claims

1. Copper compound material as contact (12, 18) material for vacuum interrupters, wherein the copper material comprises materials of the group comprising:
 - a.) tungsten carbide copper and/or chromium carbide copper and/or chromium copper and/or copper, the at least one compound element is selected from the groups comprising:
 - b.) lanthanum hexaboride and/or lanthanum oxide and/or gadolinium oxide and/or gallium oxide and/or cerium dioxide and/or material,
 - c.) graphite and/or graphene and/or fullerene and/or diamond and/or carbo nanotubes and/or multilayer graphene.
2. Copper compound according to claim 1, **characterized in that** tungsten carbide copper material of group a.) comprises 5-80 wt.-% of tungsten carbide.
3. Copper compound according to claim 1, **characterized in that** the chromium carbide copper material of group a.) is mixed in the range of 2-65 wt.-% of chromium carbide.
4. Copper compound according to claim 1, **characterized in that** the chromium copper material of group a.) is mixed in the range of 2-65 wt.-% chromium.
5. Copper compound according to one of the preceding claims, **characterized in that** the graphite, graphene, fullerene, diamond material, carbo nanotubes,

multilayer graphene of group c.) are mixed up to 8 wt.-% of the selected forms of carbon.

6. Copper compound according to one of the preceding claims, **characterized in that** the compound materials of group b.) are mixed up to 5 wt.-% of the selected compounds of group b).
7. Vacuum interrupter comprising one fixed contact (18) and one movable contact (12), wherein at least one contact (12, 18) comprises the copper compound according to one of the preceding claims.
8. Vacuum interrupter according to claim 7, **characterized in that** the contacts (12, 18) are fully made of the copper compound.
9. Vacuum interrupter according to claim 7, **characterized in that** a surface layer with up to 6 mm thickness of the contacts (12, 18) is made of the copper compound.
10. Vacuum interrupter according to claims 7 to 9, **characterized in that** at least one of the contact surfaces (16) is produced with a contact pin (24) having a height exceeding a height of a ring contact plate (22).
11. Vacuum interrupter according to claim 10, **characterized in that** the compound material for contact pin (24) is different from compound material of the rest of the ring contact plate (22).

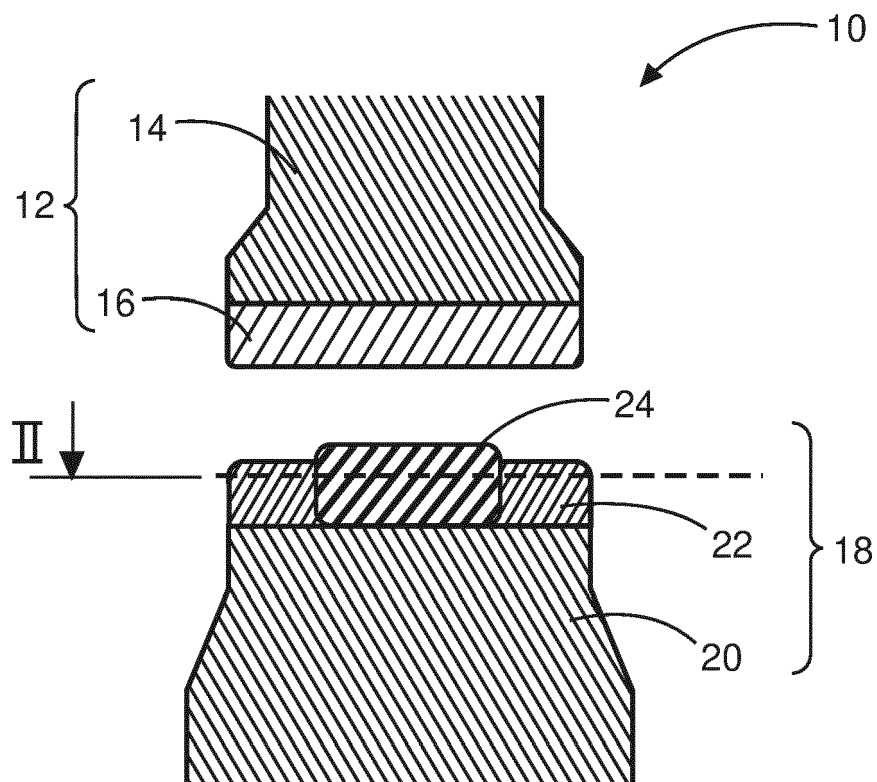


Figure 1

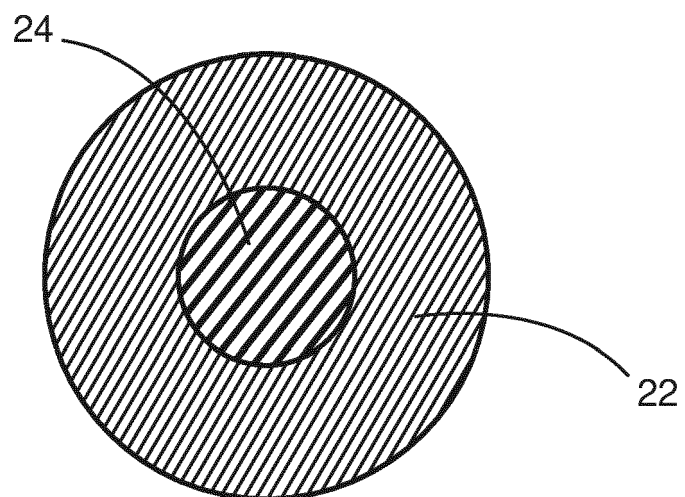


Figure 2



EUROPEAN SEARCH REPORT

Application Number

EP 23 17 0018

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EPO FORM 1503 03:82 (P04C01)

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Y	EP 1 742 238 B1 (HITACHI LTD [JP]) 3 September 2008 (2008-09-03) * paragraph [0011] - paragraph [0012] * -----	4	
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 16 November 2023	Examiner Drabko, Jacek
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 23 17 0018

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: 1-7

**Copper compound material as contact material for vacuum
interrupters**

2. claims: 8-11

The structure of contacts in a vacuum interrupter

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 23 17 0018

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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 The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

16-11-2023

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