(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 460 238 A1**

(12) **EUROPEAN PATENT APPLICATION published in accordance with Art. 158(3) EPC**

(21) Application number: **91901438.1**

(22) Date of filing: **26.12.90**

(86) International application number: **PCT/JP90/01700**

(87) International publication number: **WO 91/10238 (11.07.91 91/15)**

(51) Int. Cl.5: **H01B 7/02**, H01B 7/34, C23C 28/00, B32B 15/04, C04B 35/76

(30) Priority: **27.12.89 JP 3434/89**

(43) Date of publication of application: **11.12.91 Bulletin 91/50**

(84) Designated Contracting States: **DE FR GB IT**

(71) Applicant: **SUMITOMO ELECTRIC INDUSTRIES, LTD.**
5-33, Kitahama 4-chome, Chuo-ku
Osaka-shi, Osaka 541(JP)

(72) Inventor: **SAWADA, Kazuo Osaka Works of Sumitomo**
Electric Industries, Ltd. 1-3, Shimaya 1-chome
Konohana-ku Osaka-shi Osaka 554(JP)

Inventor: **INAZAWA, Shinji Osaka Works of Sumitomo**
Electric Industries, Ltd. 1-3, Shimaya 1-chome
Konohana-ku Osaka-shi Osaka 554(JP)

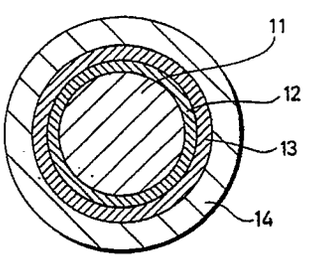
Inventor: **YAMADA, Kouichi Osaka Works of Sumitomo**
Electric Industries, Ltd. 1-3, Shimaya 1-chome
Konohana-ku Osaka-shi Osaka 554(JP)

(74) Representative: **Kirschner, Klaus Dieter et al**
Patentanwälte Herrmann-Trentepohl Kirschner Grosse Bockhorni Forstenrieder Allee 59
W-8000 München 71(DE)

(54) INSULATED WIRE.

(57) An insulated wire provided with a conductor, a first insulating metal oxide layer formed around the conductor, and a second insulating metal oxide layer formed around the first layer and including ceramic grains. The insulating metal oxide layers can be formed by converting a precursor of the metal oxide into a ceramic by a method such as a sol-gel method or a thermal decomposition method. As the ceramic grains to be mixed, microplate-like ones are preferred. This insulated wire has a high dielectric breakdown voltage, is excellent in flexibility, evolves no gas, and can keep insulation even at high temperature.

FIG. 1



EP 0 460 238 A1

Technical Field

The present invention relates to an insulated wire, and more particularly, it relates to an insulated wire, a fireproof wire or the like, which can be used under high-temperature or high-vacuum environment.

Background Art

In general, an insulated wire whose conductor is coated with heat resistant organic resin such as polyimide, fluororesin or the like has been employed in equipment such as heating equipment or a fire alarm, for which safety under a high temperature is required, or environment in an automobile, which is heated to a high temperature.

In general, further, an insulated wire whose conductor is passed through a ceramic insulator tube, or an MI cable (Mineral Insulated Cable) whose conductor is passed through a heat resistant alloy tube of a stainless steel alloy which is filled up with metal oxide particulates of magnesium oxide or the like, etc. has been employed in a case for which particularly high heat resistance is required or in environment for which a high degree of vacuum is required.

On the other hand, a fiber-glass braided insulated wire employing textile of glass fiber as an insulating member or the like can be mentioned as an insulated wire having flexibility, which can be used under high-temperature environment. As an insulated wire which is excellent in heat resistance, insulation and heat dissipativity, there exists the so-called alumite wire, which is prepared by anodizing a wire of an aluminum alloy.

Further, there has also been proposed an insulated wire which is prepared by employing a material such as a metal alkoxide or a metal organic acid salt, being changeable to a ceramics state, and forming a ceramics film around a conductor.

In the aforementioned insulated wire whose conductor is coated with heat resistant organic resin, a temperature under which insulation can be maintained is about 300 ° C at the most. Therefore, it has been impossible to apply such an insulated wire to a use for which insulation is required even under a higher temperature.

On the other hand, the aforementioned insulated wire whose conductor is passed through a ceramics insulator tube has had such a disadvantage that the same is inferior in flexibility although its insulation can be maintained under a high temperature. Further, although the aforementioned MI cable can maintain insulation under a high temperature and is flexible as compared with the aforementioned wire whose conductor is passed through a ceramics insulator tube, difficulty is caused when the same is bent with large curvature.

Further, the aforementioned fiber-glass braided insulated wire can maintain insulation even under a high temperature, and is excellent in flexibility. However, it has been impossible to use this wire under environment for which a high degree of vacuum is required, since the same easily discharges dust.

On the other hand, the aforementioned alumite wire can maintain insulation even under a high temperature, and has some flexibility. However, application of the wire has been restricted since the conductor employed for the wire is restricted to aluminum alone.

As to the aforementioned insulated wire which is prepared by forming a ceramics layer around a conductor, further, the ceramics layer is mostly a single layer having a small layer thickness, and it has been difficult to increase the breakdown voltage, although the wire is excellent in flexibility.

Disclosure of the Invention

An object of the present invention is to solve the aforementioned problems of the conventional insulated wires, and to provide an insulated wire which has the following properties:

(a) Capability of maintaining insulation even under a high temperature.
(b) Superiority in flexibility.
(c) No emission of gas.
(d) Capability of employing various types of conductors.
(e) Possession of a high breakdown voltage.

The insulated wire according to the present invention comprises a conductor, a first insulating metal oxide layer which is formed around the conductor, and a second insulating metal oxide layer, containing ceramics particles mixed by addition, which is formed around the first insulating metal oxide layer.

The first insulating metal oxide layer and/or the second insulating metal oxide layer can be formed by applying a precursor of a metal oxide containing at least one compound which is selected from a group of alkoxides or organic acid salts of Si, Zr, Aℓ and Ti to the periphery of a conductor and changing the same to a ceramics state by heating, using a method such as a sol-gel method, a thermal decomposition method or the like.

A more preferable insulated wire is implemented if the ceramics particles contained in the second insulating metal oxide layer of the present invention are in the form of a fine plate.

Further, an insulated wire having further superior flexibility is obtained when the layer thickness of the first insulating metal oxide layer is 1 to 10

μm.

In addition, it is also possible to provide an insulated wire comprising a protective coat, by coating the outer side of the second insulating metal oxide layer with an insulating material containing an organic material.

The conductor is not particularly restricted so far as the same has conductivity, and the configuration, the material etc. thereof may be selected in response to its application such as a thermocouple or a flexible printed circuit, for example.

Since the insulated wire according to the present invention comprises insulating layers of metal oxides having extremely high melting points around the conductor, it is possible to maintain insulation even under a high temperature, as compared with the conventional insulated wire which is coated with heat resistant organic resin.

Further, the insulated wire according to the present invention can be used also under high-vacuum environment, since the same emits no gas.

In the present invention, further, the insulating metal oxide layer can be increased in thickness since the ceramics particles are contained in the insulating metal oxide layer by addition, whereby it is possible to obtain an insulated wire having a high breakdown voltage.

It is difficult to increase the first insulating metal oxide layer in thickness, and an insulated wire which comprises only the first layer has a low breakdown voltage. However, since the first insulating metal oxide layer is in close contact with the conductor, it is excellent in flexibility and can maintain insulation even if the same is extremely deformed in bending or the like.

On the other hand, the second insulating metal oxide layer has high insulability since the same can be easily increased in thickness by applying a substance obtained by adding ceramics particles to a precursor of ceramics to the conductor and baking the same. If this layer alone is formed around the conductor, however, it may not be possible to maintain good insulation due to fine cracks caused in the layer when the same is extremely deformed in bending or the like, since the layer is inferior in adhesion with the conductor as well as bonding property of particles within the layer to the first insulating metal oxide layer.

Therefore, the aforementioned first layer is formed around the conductor and the aforementioned second layer is further formed around the first layer, so that fine cracks, that may be caused in the second layer by extreme deformation resulting from bending or the like, are prevented by the first layer, and it is possible to maintain high insulability over the entire insulating layers.

When alkoxides or organic acid salts of Si, Zr, Aℓ and Ti are employed as materials for the first and/or second insulating metal oxide layer, it is possible to form homogeneous insulating layer(s) by preparing a precursor of an oxide from these solutions using a method such as a sol-gel method or a thermal decomposition method, applying this precursor to the periphery of the conductor, and further carrying out baking.

Further, when the ceramics particles which are contained in the second insulating metal oxide layer by addition in advance of application are in the form of a fine plate, it is possible to obtain an insulated wire having a higher breakdown voltage.

Further, if the thickness of the first insulating metal oxide layer is 1 to 10 μm, it is possible to obtain an insulated wire having further superior flexibility.

In addition, it is also possible to use the wire as a fireproof wire by providing a protective coat which contains an organic material on the outer side of the second insulating metal oxide layer.

Brief Description of the Drawings

Fig. 1 is a sectional view of an insulated wire in which a first insulating silicon oxide layer of 5 μm in thickness and a second insulating metal oxide layer of 35 μm in thickness are formed around a nickel-plated copper wire of 1 mm in diameter according to the present invention.

Fig. 2 is a sectional view of an insulated wire which is obtained by coating three insulated wires shown in Fig. 1 with polyolefine resin mixed with magnesium hydroxide.

Best Modes for Carrying Out the Invention

Example 1

A nickel-plated copper wire of 1 mm in diameter was employed as a conductor.

1 mole percent of nitric acid was added to a mixed solution of 4 mole percent of tetraethoxysilane, 24 mole percent of water and 71 mole percent of ethyl alcohol. This solution was applied to the aforementioned nickel-plated copper wire, and thereafter baking was continuously carried out at a temperature of 500 °C, to form a first insulating silicon oxide layer of 5 μm in thickness.

Further, a substance, which was obtained by mixing 2 parts of mica of about 2 μm in mean particle diameter to 10 parts of a mixed solution of 4 mole percent of tetraethoxysilane, 1 mole percent of tetraethoxyzirconium, 1 mole percent of water and 94 mole percent of ethyl alcohol as ceramics particles, was applied to the periphery of the aforementioned first insulating silicon oxide layer, and thereafter baking was continuously carried out at a temperature of 600 °C, to form a second insulating

metal oxide layer of 35 μm in thickness.

Fig. 1 is a sectional view of an insulated wire formed by the aforementioned process.

A first insulating metal oxide layer 13 is formed around a conductor comprising a nickel-plated layer 12 which is formed around copper 11, and a second insulating metal oxide layer 14 containing ceramics particles is further formed around the same.

As to a material which was provided with only the first insulating metal oxide layer, a breakdown voltage was measured in the process of formation of such an insulated wire, whereby the result was about 500 V. Further, a breakdown voltage of an insulated wire which was provided with the second insulating metal oxide layer containing ceramics particles was measured, whereby the result was at least 1200 V.

Thus, it has been clarified that an insulated wire having a high breakdown voltage can be obtained according to the present invention.

Even if the insulated wire formed by the aforementioned process was held under a temperature of 850°C for 30 minutes, insulation was maintained. Thus, it has been clarified that the insulated wire obtained according to the present invention can maintain insulation even under a high temperature.

Example 2

Three insulated wires obtained in Example 1 were employed, and these three wires were coated with polyolefine resin mixed with magnesium hydroxide, to obtain a single wire.

Fig. 2 is a sectional view of the wire thus obtained. Three insulated wires 21 are gathered and respectively coated with polyolefine resin 22 mixed with magnesium hydroxide, to form a single wire.

This wire continuously served as a wire even if the same was held under a temperature of 850 degrees for 30 minutes.

Industrial Applicability

As hereinabove described, the insulated wire according to the present invention can maintain insulation even under a high temperature, is excellent in flexibility, emits no gas, can use various types of conductors, and is advantageously applicable to an insulated wire, a fireproof wire, a thermocouple and a flexible printed circuit etc., for which a high breakdown voltage is required.

Claims

1. An insulated wire comprising a conductor, a first insulating metal oxide layer being formed around said conductor, and a second insulating metal oxide layer, containing ceramics particles mixed by addition, being formed around said first insulating metal oxide layer.

2. An insulated wire in accordance with claim 1, wherein said first insulating metal oxide layer and/or said second insulating metal oxide layer is formed by baking a precursor containing at least one compound selected from a group of alkoxides or organic acid salts of Si, Zr, Aℓ and Ti.

3. An insulated wire in accordance with claim 1 or 2, wherein said ceramics particles are in the form of a fine plate.

4. An insulated wire in accordance with any one of claims 1 to 3, wherein the thickness of said first insulating metal oxide layer is within a range of 1 to 10 μm.

5. An insulated wire in accordance with any one of claims 1 to 4, further comprising a protective coat, containing an organic material, on the outer side of said second insulating metal oxide layer.

FIG. 1

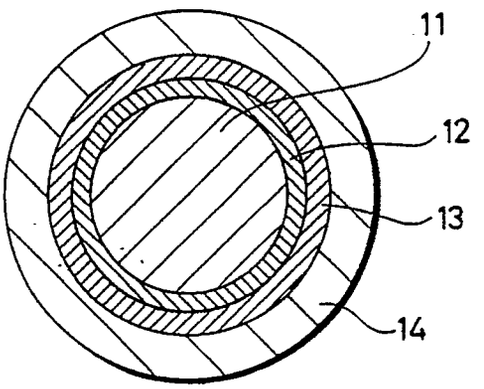
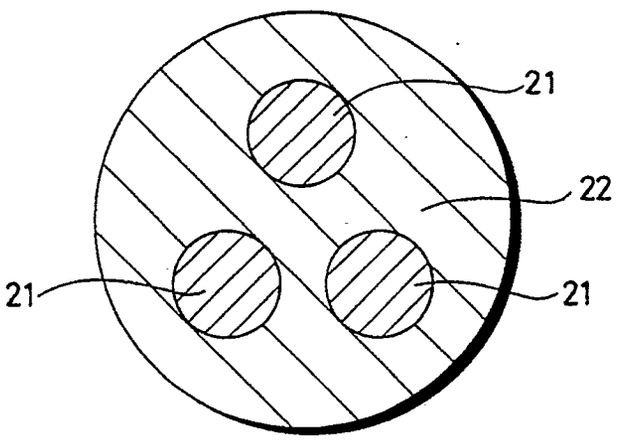


FIG. 2



INTERNATIONAL SEARCH REPORT

International Application No PCT/JP90/01700

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl[5] H01B7/02, H01B7/34, C23C28/00, B32B15/04, C04B35/76

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	H01B7/02, H01B7/34, C23C28/00, B32B15/04, C04B35/76

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho 1926 - 1991
Kokai Jitsuyo Shinan Koho 1971 - 1991

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	JP, A, 53-136009 (Riken Kei Kinzoku Kogyo K.K.), November 28, 1978 (28. 11. 78), (Family: none)	1, 3-4
A	JP, A, 58-18809 (Sumitomo Electric Industries, Ltd.), February 3, 1983 (03. 02. 83) & US, A, 4476192 & JP, B2, 63-67284	1, 3
P	JP, A, 2-38585 (GTE Laboratories Inc.), February 7, 1990 (07. 02. 90) & DE, A, 3919307 & US, A, 4943450 & US, A, 4965140	1
P	JP, A, 2-123618 (Optic DD. Merck Laboratory K.K.), May 11, 1990 (11. 05. 90), (Family: none)	1-2, 5

* Special categories of cited documents: [10]

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
March 1, 1991 (01. 03. 91)	March 18, 1991 (18. 03. 91)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	