CONDUCTIVE YARN CAPABLE OF WITHSTANDING DYEING, FINISHING AND WASHING

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ABSTRACT

The invention discloses a conductive yarn including a core yarn and at least one rolled metal wire with a corrosion or oxidation protection which is respectively and spirally wound around the core yarn. The conductive yarn according to the invention is capable of withstanding dyeing, finishing and washing, and has excellent stress resistance, better conductivity, yarn softness and flexibility such that it can be easily in a conventional textile fabrication process to become a conductive portion of textile article or be served as a conductive sewing thread. Moreover, according to the invention, the conductive yarn provides an intimate structure between the surface conductive material (rolled metal wires) and core material (core yarn). The structure can ensure the surface conductive material will not be fractured, and have a better and uniform conductivity.
FIG. 2B

FIG. 2C
CONDUCTIVE YARN CAPABLE OF WITHSTANDING DYING, FINISHING AND WASHING

BACKGROUND OF THE INVENTION

1. Field of the Invention
This present invention relates to a conductive yarn, and more in particular, to a conductive yarn capable of withstanding dyeing, finishing and washing.

2. Description of the Prior Art
It is well known that conductive yarns used in textile articles made in various textile ways serves as circuitry, physiological detectors, electrodes, and other wearable electronic devices.

Just like manufacture of general textile articles, conductive yarns and wearable electronic devices made of such conductive yarns during manufacture thereof are to be experienced dyeing and finishing procedures (including yarn dyeing, fabric dyeing), and washing procedures. Therefore, the conductive yarns are bound to be subjected to attack of acidic or alkaline dye bath, oxidizing agents, reducing agents, deters, bleaches, and so on. In addition, during the procedures and using, the conductive yarns always suffer from very complicated stresses and can be easily fractured. Finally, the conductive yarn loses the conductivity and quality.

One prior art regarding conductive yarns uses traditional copper wires with excellent conductivity to be conductive yarns. However, copper wires are not suitable to be used as material of the conductive yarns because the copper wire is too stiff to be a yarn for textile fabrication processes, and copper doesn't perform well in oxidation and corrosion.

One other prior art regarding conductive yarns uses polymer filaments with conductive particles doping or plating to form conductive yarns or filaments. However, the doping or plating procedure takes higher cost, and the conductivity of the conductive yarns or filaments is much lower than that of the metal wire. In addition, the conductive polymer yarns or filaments cannot be welded upon the traditional electronic device with traditional electronic skills.

One other prior art regarding conductive yarns uses enamel covered copper wires as raw material to form conductive yarns. However, during manufacture of a wearable electronic device utilizing such conductive yarns, the enamel covered copper wires need to be peeled to bare the copper wires therein. and the peeling procedure of the enamel covered copper wires needs to be performed by immersing the enamel covered copper wires in chemicals. Hence, the use of the enamel covered copper wires as raw material to form conductive yarns cannot still prevent from corrosion problem.

Referring to FIGS. 1A and 1B, those figures disclose another prior art regarding conductive yarns. FIG. 1A illustratively shows the structure of a conductive yarn 10 disclosed in specification of U.S. Pat. No. 5,927,060. FIG. 1B is a sectional view of the conductive yarn 10 shown in FIG. 1A along the A-A line.

As shown in FIG. 1A, the conductive yarn 10 according to the prior art includes a core yarn 12 constituted by a plurality of synthetic filaments. The core yarn 12 is covered by at least two up to at most four metal filaments of stainless steel. The core yarn 12 of the example shown in FIG. 1A is covered by a metal filament 14 and another metal filament 16 extending in a direction opposite that of the metal filament 14.

However, as shown in FIG. 1A, the metal filaments (14, 16) do not fully cover the core yarn 12. During dyeing, finishing, washing and using of the conductive yarn 10, complicated mechanical stresses introduced by processing environment or using environment, is extremely likely to apply a higher thrust F to the metal filaments (14, 16), as shown in FIG. 1B. Moreover, as shown in FIG. 1B, the contact area of the metal filaments (14, 16) with the contact surface of the core yarn 12 wound by the metal filaments (14, 16) is very narrow and even nearly equal to a fine. Because the shear stress is \( \tau = F/A \) where \( \tau \) represents the shear stress, \( F \) represents the thrust (shear force), and \( A \) represents the contact surface (shear surface), it is obvious that processing environment or using environment make the metal filaments (14, 16) extremely vulnerable to environment-induced shear stress such that the metal filaments (14, 16) are subsequently shifted from the original winding location on the contact surface of the core yarn 12, and even pushed away from the core yarn 10, and finally broke. Therefore, the conductive yarn shown in FIG. 1A of the prior art in the long-term easily loses its conductivity, and the metal filament fragments make wearers feel uncomfortable or itchy.

In addition, the metal filament (14, 16) is difficult to hold the core yarn 10 because the contact surface between the wire and the core yarn is very small, and the elongation of metal filament (14, 16) is difficult to match the elongation of the core yarn 10, hence the fabrication process can easily cause the protuberance of the metal filament (14, 16).

SUMMARY OF THE INVENTION

Accordingly, one aspect of the invention is to provide a conductive yarn. And in particular, the conductive yarn according to the invention is capable of withstanding dyeing, finishing and washing, and has excellent stress resistance, better conductivity, softness and flexibility such that it can be easily used in a conventional textile fabrication process such as weaving, knitting and braiding to become a conductive portion of textile article or be served as a conductive sewing thread. Moreover, according to the invention, the conductive yarn provides an intimate structure between the surface conductive material (rolled metal wires) and core material (core yarn). The intimate structure can ensure the surface conductive material will not be fractured, and have a better and uniform conductivity.

According to a preferred embodiment of the invention, the conductive yarn structure includes a core yarn and at least one rolled metal wire with corrosion or oxidation protection. The core yarn is constituted by at least one conductive core wire or filament with corrosion or oxidation protection, at least one short metal fiber yarns of with corrosion or oxidation protection, at least one non-conductive core filament or at least one non-conductive short fiber yarn. The at least one rolled wire is respectively and spirally wound around the core yarn.

In one embodiment, materials used to fabricate the at least one rolled metal wire with corrosion or oxidation protection, the at least one conductive wire or filament with corrosion or oxidation protection and the at least one short metal fiber yarns with corrosion or oxidation protection respectively can be tin plating copper, gold plating copper, nickel plating copper, stainless steels (e.g., 316, 304, 420, containing copper stainless steel, and containing silver stainless steel), titanium, titanium alloys (e.g., TA0, TA1, TA2, TA3, TA7, TA9, TA10, TC1, TC2, TC3, TC4(Ti6Al4V)).
nickel, silver, gold, nichrome, Ni—Cr—Mo—W alloys, tungsten, platinum, palladium, zirconium, zirconium alloys (e.g., alloy 702, alloy 704, alloy 705, alloy 706), tantalum, CuNi alloys, CuNiSi alloy, CuNiSn alloys, CuCr alloys, CuAg alloys, CuW alloys, HASTELLOY type alloys (e.g., alloy C-22, alloy B-2, alloy C-22), NICKEL type alloys (e.g., Nickel 200, Nickel 201), MONEL type alloys (e.g., alloy 400, alloy R-405, alloy K-500), INCONEL type alloys (e.g., alloy 600, alloy 625), FERRALIUM type alloys (alloy 255), NITRONIC type alloys (e.g., NITRONIC 50, NITRONIC 50, NITRONIC 50, CARPENTER type alloys (alloy 20Cb-3), or other commercial of corrosion-resistant metals or alloys.

[0016] The material used to fabricate aforementioned non-conductive core filament and the non-conductive short fibers can be polyester, polyamide, polyacrylic, polyethylene, polypropylene, cellulose, protein, elastomeric, polytetrafluoroethylene, poly-p-phenylenedibenzosiazole (PBO), polyetherketone, carbon, glass fiber, or other commercial materials to make non-conductive yarns.

[0017] The aspect of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment, which is illustrated in the following figures and drawings.

BRIEF DESCRIPTION OF THE APPENDED DRAWINGS

[0018] FIG. 1A illustratively shows a structure of a conductive yarn 10 according to the prior art.

[0019] FIG. 1B is a sectional view of the conductive yarn shown in FIG. 1A along the A-A line.

[0020] FIG. 2A illustratively shows a structure of a conductive yarn 20 according to a preferred embodiment of the invention.

[0021] FIG. 2B is a sectional view of the metal wire 24 without rolling shown in FIG. 2A along the C-C line and a sectional view of the rolled metal wire 24 shown in FIG. 2A along the C’-C’ line.

[0022] FIG. 2C is a sectional view of the conductive yarn shown in FIG. 2A along the B-B line.

[0023] FIG. 3A is an SEM photograph of the conductive yarn 20 according to the preferred embodiment of the invention.

[0024] FIG. 3B is another SEM photograph showing the magnified view of a distal end of the conductive yarn 20 shown in FIG. 3A.

DETAILED DESCRIPTION OF THE INVENTION

[0025] Some preferred embodiments and practical applications of this present invention would be explained in the following paragraph, describing the characteristics, spirit and advantages of the invention.

[0026] Referring to FIGS. 2A, 2B and 2C, the FIG. 2A illustratively shows a structure of a conductive yarn 20 according to a preferred embodiment of the invention. FIG. 2B is a sectional view of the metal wire 24 without rolling shown in FIG. 2A along the C-C line and a sectional view of the rolled metal wire 24 shown in FIG. 2A along the C’-C’ line. FIG. 2C is a sectional view of the conductive yarn shown in FIG. 2A along the B-B line.

[0027] As shown in FIG. 2A, the conductive yarn 20 according to the preferred embodiment of the invention includes a core yarn 22 and at least one rolled metal wire 24 with corrosion or oxidation protection.

[0028] In practical application, the core yarn 22 is constituted by at least one conductive core wire or filament with corrosion or oxidation protection, at least one short metal fiber yarns with corrosion or oxidation protection, at least one non-conductive core filament or at least one non-conductive short fiber yarn. In the embodiment shown in FIG. 2A, the core yarn 22 is constituted by a plurality of core filaments 22.

[0029] According to the preferred embodiment of the invention, at least one rolled metal wire 24 is respectively and spirally wound around the core yarn 22. In the embodiment shown in FIG. 2A, the core yarn 22 is spiral wound around by the rolled metal wires 24. In practical application, the number of the rolled metal wires 24 spirally winding around the core yarn 22 depends on practical requirement of the conductive yarn 20, such as conductivity, softness, flexibility, mechanical properties, and so on.

[0030] Also shown in FIG. 2A, there is gap existing between neighboring encircles of the same rolled metal wire 24 wound around the core yarn 22. In practical application, according to practical requirement of the conductive yarn 20, such as conductivity, softness, flexibility, and mechanical properties, etc., the neighboring encircles of the same rolled metal wire 24 wound around the core yarn 22 might be overlapped partially.

[0031] In one embodiment, materials used to fabricate the at least one rolled metal wire 24 with corrosion or oxidation protection, the at least one conductive core wire or filament 22 with corrosion or oxidation protection and the at least one short metal fiber core yarns 22 with corrosion or oxidation protection respectively can be tin plating copper, gold plating copper, nickel plating copper, stainless steels (e.g., 316, 304, 420, containing copper stainless steel, and containing silver stainless steel), titanium, titanium alloys (e.g., TA0, TA1, TA2, TA3, TA7, TA9, TA10, TC1, TC2, TC3, TC4 (Ti6Al4V)), nickel, silver, gold, nichrome, Ni—Cr—Mo—W alloys, tungsten, platinum, palladium, zirconium, zirconium alloys (e.g., alloy 702, alloy 704, alloy 705, alloy 706), tantalum, CuNi alloys, CuNiSi alloys, CuNiSn alloys, CuCr alloys, CuAg alloys, CuW alloys, HASTELLOY type alloys (e.g., alloy C-22, alloy B-2, alloy C-22), NICKEL type alloys (e.g., Nickel 200, Nickel 201), MONEL type alloys (e.g., alloy 400, alloy R-405, alloy K-500), INCONEL type alloys (e.g., alloy 600, alloy 625), FERRALIUM type alloys (alloy 255), NITRONIC type alloys (e.g., NITRONIC 50, NITRONIC 50, NITRONIC 50, CARPENTER type alloys (alloy 20Cb-3), or other commercial corrosion-resistant metals or alloys.

[0032] In one embodiment, material used to fabricate aforementioned non-conductive core filament and the non-conductive short fibers can be polyester, polyamide, polyacrylic, polyethylene, polypropylene, cellulose, protein, elastomeric, polytetrafluoroethylene, poly-p-phenylenedibenzosiazole (PBO), polyetherketone, carbon, glass fiber, or other commercial materials to make non-conductive yarns.

[0033] According to the preferred embodiment of the invention, the structure of conductive yarn 20 can designed according to functional requirement such yield tension, yield torsion, fire resistance, conductivity and so on.

[0034] As shown in FIG. 2B, the metal wire 24 without rolling has a length l, a diameter d, and a volume equal to \( \pi (d/2)^2t \), and has the contact area with the core yarn 22 nearly...
equal to a line. Also shown in FIG. 2B, the rolled metal wire 24, similarly with a length $t$, has a thickness $d/5$ and a volume equal to that of the metal wire 24 without rolling, and has the contact area with the core yarn 22 equal to 4dxL.

[0035] Obviously, different from the prior art, the invention is to roll the metal wire to get the rolled metal wire having identical volume to that of the metal wire without rolling and but the larger contact area with the core yarn where the rolled metal wire is spirally wound around the core yarn. By tightly winding the rolled metal wire 24 around the core yarn 22, the conductive yarn 20 according to the invention has considerable compliance between the core yarn 22 and the rolled metal wire 24. More importantly, during the dyeing, finishing, washing and using of the conductive yarn 20, it is very likely to apply a higher thrust $F$ to the rolled metal wire 24, as shown in FIG. 2C. And as shown in FIG. 2C, the rolled metal wire 24 is completely cover the core yarn 22 and has the larger contact area with the core yarn 22. It is obviously that the environment-induced shear stress exerting on the environment of the rolled metal wire 24 is much higher than the environment-induced shear stress exerting on the metal wire without rolling of the prior art, such that the rolled metal wire 24 is very difficult to be removed from the original position, or cannot be pushed away from the core yarn 22, or cannot be fractured.

[0036] In addition, in FIG. 2B, the cover width $4d$ of the rolled metal wire can be easily adjusted by rolling force according to the demand of softness of the conductive yarn.

[0037] The smaller the cover width is, the softer the conductive yarn is. However, the smaller the cover width is, the weaker the stress resistance is. The conductive yarn 20 according to the invention has excellent yarn softness and flexibility such that it is available to be easily woven in a conventional textile way into a conductive portion of a textile article, or to be served as a conductive sewing thread. The fabrication process would not cause any protuberance of the rolled metal wire 24 because the rolled metal wire 24 with large cover width can hold the core yarn 22 much tied.

[0038] In addition, in FIG. 2A, the layer of the rolled metal wire is at least one layer. The number of the layer can be increased by increasing number of the metal wire during the rolling procedure to increase the conductivity. Furthermore, the excellent stress resistance also ensures a uniform conductivity.

[0039] During dyeing, finishing, washing and using of the conductive yarn 20, it is obviously that the conductive yarn 20 is capable of resisting corrosion resulting from for example acidic or alkaline agent, oxidant, reducing agent, detergent, bleach and so on, and maintains its original conductivity. Furthermore, the conductive yarn 20 according to the invention has excellent yarn softness and flexibility such that it can be easily used in a conventional textile fabrication process such as weaving, knitting and braiding to become a conductive portion of textile article or be served as a conductive sewing thread.

[0040] Also shown in FIG. 2A, according to another preferred embodiment of the invention, at least one rolled metal wire is also pressed in a pattern during being rolled by a pattern carved roller. In this way, the surface of the at least one rolled metal wire 24 has the corresponding pattern 26. The surface of the rolled metal wire 24 can provide different light refractions to produce different visual effects by use of different patterns 26. In addition, the rolled metal wire 24 with pattern of the invention can also provide anti-counterfeiting features by use specific patterns 26.

[0041] Referring to FIG. 3A and FIG. 3B, FIG. 3A is an SEM photograph of the conductive yarn 20 according to the preferred embodiment of the invention. FIG. 3B is another SEM photograph showing the magnified view of a distal end of the conductive yarn 20 shown in FIG. 3A. As shown in FIG. 3A, the rolled metal wire 24 completely covers the core yarn 22 constituted by a plurality of filament, and has large contact area with the core yarn 22. As shown in FIG. 3B, the conductive yarn 20 has considerable compliance between the core yarn 22 and the rolled metal wire 24. That is, the conductive yarn 20 according to the invention provides an intimate structure between the surface conductive material (rolled metal wires) and core material (core yarn). The intimate structure can ensure the surface conductive material will not be fractured, and have a better and uniform conductivity.

[0043] With the example and explanations above, the features and spirits of the invention will be hopefully well described. Those skilled in the art will readily observe that numerous modifications and alterations of the device may be made while retaining the teaching of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

What is claimed is:

1. A conductive yarn, comprising:
   a core yarn selected from the group consisting of at least one conductive core wire or filament with corrosion or oxidation protection, at least one short metal fiber yarns with corrosion or oxidation protection, at least one non-conductive core filament or at least one non-conductive short fiber yarn; and
   at least one rolled metal wire with corrosion or oxidation protection spirally winding around the core yarn;
   whereby said conductive yarn is capable of withstanding dyeing, finishing and washing.

2. The conductive yarn of claim 1, wherein said at least one conductive core wire or filament with corrosion or oxidation protection, said at least one short metal fiber yarns with corrosion or oxidation protection and said at least one rolled metal wire with corrosion or oxidation protection respectively are one selected from the group consisting of tin plating copper, gold plating copper, nickel plating copper, stainless steel, titanium, titanium alloys, nickel, silver, gold, nichrome, Ni—Cr—Mo—W alloys, tungsten, platinum, palladium, zirconium, zirconium alloys, tantalum, CuNi alloys, CuNiSi alloys, CuNiZn alloys, CuNiSn alloys, CuCr alloys, CuAg alloys, CuW alloys, HASTELLOY type alloys, NICKEL type alloys, MONEL type alloys, ICONEL type alloys, FERRALIUM type alloys, NITRONIC type alloys, and CARPENTER type alloys.

3. The conductive yarn of claim 1, wherein at least one rolled metal wire is also pressed in a pattern during being rolled by a pattern carved roller.

4. The conductive yarn of claim 1, wherein the at least one non-conductive core filament and the at least one non-conductive short fiber yarn are made of a material selected from the group consisting of polyester, polyamide, polyacrylic, polyethylene, polypropylene, cellulose, protein, elastomeric, polytetrafluoroethylene, poly-p-phenylenebenzobisoxazole (PBO), polyetherketone, carbon, and glass fiber.

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