Title: CONDUCTIVE YARN FOR ELECTRONIC TEXTILE APPLICATIONS

Abstract: An electrically conductive yarn (2) having a multifilament core (5) comprising a plurality of electrically conductive filaments (4), and a wrapping (6, 10) arranged around the multifilament core. The wrapping is arranged to partly expose the multifilament core, thereby reducing an occurrence of short-circuiting between adjacent electrically conductive yarns while enabling electrical connection of electronic components to the multifilament core. The present invention also relates to a method of manufacturing thereof.
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Conductive yarn for electronic textile applications

TECHNICAL FIELD OF THE INVENTION
The present invention relates to an electrically conductive yarn having a multifilament core comprising a plurality of electrically conductive filaments, and a wrapping arranged around the multifilament core.

BACKGROUND ART
Many types of textiles are used in our every day life. When electronics is integrated into these textiles, new application fields emerge. The integration of microelectronic devices in textiles can be very useful for communication and monitoring purposes, in various application areas such as health care, sports and rehabilitation, occupational wear, gaming, etc. Furthermore, light-emitting textiles open up a wide range of new interior and apparel applications, ranging from illumination to atmosphere creation or messaging.

Applications for, for instance, soft lighting and wearable light therapy may be realized by incorporating arrays of LED packages into textiles. Very compact, low-power LED packages are available as surface mounted devices (SMD), which can be attached to the fabric by gluing, snap button connection or stitching.

Electronic conductors to which the LED packages and other electronic modules such as connectors, antennas, etc. can be connected, are usually realized by conductive yarns, which may be either woven, knitted or embroidered into the fabrics and/or non-vowen structures. Such conductive yarns may for instance be formed of metal, such as stainless steel, and be twisted with non-metallic yarns and fibers. Weaving and embroidery, however, impose mechanical requirements on the conductive yarns, and for weaving, the best results are usually obtained using textile-like materials, such as polyester or polyamide.

Therefore, the conductive yarn may also be formed of a plurality of non-conductive filaments, each coated with a conductive metal layer.

Textiles utilized for electronic applications usually comprise a plurality of these conductive yarns, provided across the fabric. The presence of several conductive yarns close to one another might, however, pose a problem. Failing in keeping the conductive yarns
separated over time may viz results in short circuiting between adjacent conductive yarns, thus causing the electronic application to malfunction.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an electrically conductive yarn of the type mentioned by way of introduction, a method for manufacturing the same, a fabric comprising such an electrically conductive yarn, and an electronic textile comprising such a fabric, in which the above related drawback is eliminated wholly or at least partly.

According to a first aspect of the invention, an electrically conductive yarn is provided, having a multifilament core comprising a plurality of electrically conductive filaments, and a wrapping arranged around the multifilament core. The wrapping is arranged to partly expose the multifilament core, thereby reducing an occurrence of short-circuiting between adjacent electrically conductive yarns while enabling electrical connection of electronic components to the multifilament core.

The invention likewise concerns a method of manufacturing an electrically conductive yarn of the kind defined above. Thus, according to a second aspect of the invention, there is provided a method of manufacturing an electrically conductive yarn having a multifilament core comprising a plurality of electrically conductive filaments. The method comprises the step of arranging a wrapping around the multifilament core such that the multifilament core is partly exposed, thereby reducing an occurrence of short-circuiting between adjacent electrically conductive yarns while enabling electrical connection of electronic components to the multifilament core.

An electrically conductive yarn may comprise a plurality of conductive filaments, perhaps as many as 50-300. It is however likely that some of the filaments, by for instance tear, are worn off somewhere along the conductive yarn during production or use. These worn off filaments are prone to protrude from the conductive yarn, and as textiles utilized for electronic applications usually comprise a plurality of conductive yarns provided across the fabric, filaments sticking out from a conductive yarn may, as discussed in the foregoing, pose a problem with regards to possible short circuiting with adjacent conductive yarns.

The inventors have realized that by preventing the filaments in a conductive yarn from separating, this can be avoided. Thus, by providing a wrapping in accordance with the present invention, i.e. arranging a wrapping around a multifilament core leaving the
multifilament core partly exposed, the risk of short-circuiting between adjacent conductive yarns is reduced. The wrapping, which formation preferably is consistent throughout the length of the multifilament core, partly encloses the core, thereby preventing worn off filaments from protruding from the core and getting in contact with adjacent yarns. Since the wrapping leaves the multifilament core partly exposed, electrical connection of electronic components to the multifilament core is, however, yet possible. Electronic components, such as LEDs, can thus be attached to the multifilament core although the wrapping encloses the core. The ability to connect electronic components directly to the core is advantageous, as the core comprises a plurality of conductive filaments, thereby providing good conductivity.

Consequently, textiles comprising electrically conductive yarns in accordance with the present invention enable for electronic textile applications to be realized, while short-circuiting between adjacent conductive yarns is prevented.

Additionally, the wrapping partly protects the filaments from wear, as the wrapping limits the effects caused by exposure to air, moisture, chemicals and more importantly abrasion from rubbing the conductive surfaces against other objects, including other textile yarns, during production, usage and care. That is to say, the wrapping contributes to preventing filaments from being worn off, and the conductive yarn according to the present invention subsequently contributes to avoiding decreased conductivity.

For connection of electrical components to the multifilament core along its longitudinal direction, part of an envelope surface of the multifilament core must naturally be exposed, and the wrapping is preferably arranged in such a way that a covered portion of the envelope surface of the multifilament core is smaller than an uncovered portion of the envelope surface. The term "envelope surface" of the multifilament core is, in the context of this application, to be understood in a broad sense, meaning the surface area of the core in its longitudinal direction. The uncovered portion enables electrical components to be connected to the multifilament core, while the covered portion prevents filaments from becoming separated. As the formation of the wrapping may differ from one conductive yarn to another, so may the ratio between the covered and uncovered portions of the envelope.

The electrically conductive filaments may preferably be provided throughout the core of the electrically conductive yarn, from a center to a perimeter thereof. Arranging the filaments in this manner, they will provide good conductivity and textile characteristics.

For weaving conductive yarns into fabrics, conductive yarns of textile-like materials are usually preferred. Consequently, according to the present invention, the electrically conductive filaments may each comprise a non-conductive filament, for instance...
a polyamide or polyester filament, provided with a conductive coating. The thin conductive layer does not significantly change the thread properties. The conductive coating may preferably be a metal coating, for instance silver, thin enough to be undamaged in the textile processing. The choice of the metal content further determines the conductivity of the filament.

In order to provide the multifilament core with a wrapping exposing the core and yet preventing separation of the filaments, the wrapping may comprise a wrapping yarn, which is wound around the multifilament core in a first winding direction to form a single spiral structure. Preferably, a period of the spiral is greater than twice, and smaller than six times a diameter of the wrapping yarn. A wrapping in accordance with this embodiment, comprising a wrapping yarn wound around the multifilament core along the longitudinal direction of the core, exposes the multifilament core, thus enabling for electronic components to be connected to the core while preventing filaments from protruding there from.

Additionally, according to an alternative embodiment, the wrapping may comprise a further wrapping yarn wound around the multifilament core in a second winding direction, opposite the first winding direction, thereby forming a double spiral structure. Providing a double spiral structure in this manner enables, for instance, use of a thinner wrapping yarn than is possible for the embodiment utilizing a single spiral wrapping structure. Additionally, the double spiral structure presents a more homogeneous conductive yarn, i.e. more isotropic, thus easier to weave.

It is furthermore preferred that a diameter of the wrapping yarn is smaller than a diameter of the multifilament core, preferably smaller than 75% thereof. Further, the wrapping yarn may be a staple yarn, as well as a monofilament or a multifilament yarn.

Alternatively to wrappings comprising wrapping yarns as discussed above, the wrapping of an electrically conductive yarn in accordance with the present invention may be arranged to form a net structure around the multifilament core. In this case, the open net structure leaves the multifilament core easily accessible, and the wrapping according to this embodiment likewise enables electrical components to be connected to the multifilament core while protrusion of worn off filaments through the wrapping is prevented.

According to one embodiment, the wrapping is electrically conductive. Utilizing a conductive wrapping facilitates the connection of electrical components, as the possibility of connection is not restricted to the conductive multifilament core, but extended also to include the conductive wrapping. A conductive wrapping further increases the overall conductivity.
Alternatively, the wrapping may likewise be non-conductive. A non-conductive wrapping has the advantage that it is robust upon soft forces such as wrinkling, that is to say, the wrapping contributes to avoidance of shortcircuiting between conductive yarns during wrinkling. Connection of electronic components to the multifilament core can be made by pushing the non-conductive wrapping aside at the points where attachment of components is required.

Furthermore, the multifilament core is preferably twisted. Twisting further locks the structure, which enhances yarn strength as well as prevents worn off filaments from protruding from the structure. Twisting also increases the contact area between single filaments, which can enhance conductivity. The level of twist should be determined based on desired strength, conductivity, bending rigidity, etc. of the complete yarn structure.

In manufacturing the electrically conductive yarn in accordance with the present invention, arranging the wrapping around the multifilament core may include providing a preformed wrapping around the multifilament core. Providing a preformed wrapping may facilitate the manufacturing process, as the wrapping for instance can be thread upon the multifilament core during production of the conductive yarn. The preformed wrapping may for instance be a knitted, open structured wrapping, adapted for partly enclosing the multifilament core.

Additionally, the conductive yarn according to the present invention may, furthermore, advantageous be comprised in a fabric for connection of electronic components thereto.

Yet further, the fabric according to the present invention may advantageously be comprised in an electronic textile comprising at least one electronic component connected thereto.

Fabrics comprising electrically conductive yarns in accordance with the present invention and electronic textiles comprising these fabrics consequently enable for electronic textile applications to be realized, while short-circuiting between adjacent conductive yarns is prevented.

Additionally, as discussed in the foregoing, fabrics comprising conductive yarns in accordance with the present invention and electronic textiles comprising these fabrics will, due to the wrapping protecting the core filaments from wear, prevent loss of functionality caused by worn off filaments and, subsequently, decreased conductivity.

Other aspects, benefits and advantageous features of the invention will be apparent from the following description and claims.
BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more apparent from the accompanying drawings, which are provided by way of non-limiting examples.

Fig. 1 shows a textile comprising electrically conductive yarns according to a first embodiment of the present invention.

Fig. 2 illustrates the embodiment in Fig. 1 in greater detail, showing a plurality of conductive yarns woven into the fabric.

Fig. 3 illustrates one of the conductive yarns according to the first embodiment, showing a wrapping yarn arranged around a conductive multifilament core.

Fig. 4 illustrates the one of the filaments of the conductive yarn in Fig. 3 in greater detail, showing that each of the conductive filaments comprises a non-conductive filament provided with a conductive coating.

Fig. 5 shows a conductive yarn according to a second embodiment, with a further wrapping yarn arranged around the multifilament core.

Fig. 6 shows a conductive yarn according to a third embodiment, with a net structure wrapping arranged around the multifilament core.

Fig. 7 is a flow chart illustrating steps of manufacturing the conductive yarn shown in Fig. 6.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

In the following detailed description, preferred embodiments of the present invention will be described. However, it is to be understood that features of the different embodiments are exchangeable between the embodiments and may be combined in different ways, unless anything else is specifically indicated. It may also be noted that, for the sake of clarity, the dimensions of certain components illustrated in the drawings may differ from the corresponding dimensions in real-life implementations of the invention.

In Fig. 1, a textile 1 comprising a plurality of electrically conductive yarns according to a first embodiment of the present invention is shown. Though the textile 1 in this example is a sweater, the invention is not restricted thereto. A variety of textile substrates 1, including non-wovens and/or polymer films, are as well feasible. The integration of conductive yarns 2 into the textile 1 in combination with attachment of electronics (not shown) to the conductive yarns 2 enable for, for instance, realization of a light-emitting textile 1. The electronics, such as for instance very compact, low-power LED packages
available as surface mounted devices (SMD), may be attached to the textile 1 by for instance
gluing, snap button connection or stitching.

Fig. 2 shows the textile 1 in Fig. 1 in greater detail, revealing how the
conductive yarns 2 can be woven into the fabric 3. The weaving pattern in Fig. 2 is, however,
exemplifying and the invention is not restricted thereto. On the contrary, the number of
conductive yarns 2 comprised in a textile 1 may differ from one textile 1 to another, the
conductive yarns 2 may run in other directions than shown, be further separated etc.; the
options are endless. Further, the structure may also be knitted.

Fig. 3 illustrates an enlarged view of a conductive yarn 2 shown in Fig. 2. It
can be seen that the conductive yarn 2 comprises a plurality of conductive filaments 4,
perhaps as many as 50-300, forming a conductive multifilament core 5. The filaments 4 are
preferably, although not necessarily, provided throughout the core 5, from a center to a
perimeter thereof as shown if Fig. 3.

Enclosing the multifilament core 5 is a wrapping, for instance a staple yarn, or
a monofilament or a multifilament yarn. In the example, the wrapper is in the form of a
wrapping yarn 6 wound around the core 5 to form a single spiral structure. The diameter of
the wrapping yarn 6 is preferably smaller than 75% of the diameter of the multifilament
core 5, although not restricted thereto. The wrapping prevents the filaments 4 from separating
from the core 5, thus prevents conductive filaments 4 from one conductive yarn 2 to come
into contact with an adjacent conductive yarn 2. Subsequently, short-circuiting between
adjacent conductive yarns 2 is avoided.

While the wrapping prevents filaments 4 from protruding from the
multifilament core 5, at the same time it allows for electronic components (not shown) to be
connected to the conductive core 5. The wrapping thus partly exposes the core 5 such that
components can be attached to the core along its longitudinal direction. Preferably a covered
portion of an envelope surface 7 of the core 5, i.e. the portion of the surface area of the core 5
in its longitudinal direction covered by the wrapping, is smaller than an uncovered portion of
the envelope surface 7. The invention is, however, not restricted thereto. The period of the
single spiral of the wrapping yarn 6 is preferably, although not necessarily, greater than
twice, and smaller than six times the diameter of the wrapping yarn 6.

Further, the wrapping may be either electrically conductive or non-conductive.
In the case of an electrically conductive wrapping, electronic components can be connected
not only to the multifilament core 5, but also to the wrapping. In the case of a non-conductive
wrapping, the wrapping can, if necessary, be pushed aside at the points where connection of
electronic components to the conductive core 5 is required.

The filaments 5 may be 100% metallic (e.g. silver). However, in order to
facilitate weaving conductive yarns 2 into a fabric, a conductive yarn 2 of textile-like
materials is, although not required, preferred. Fig. 4 thus shows an enlarged view of a
filament 4 of the conductive yarn 2 shown in Fig. 3, revealing that the electrically conductive
filaments 4 according to the first embodiment each comprises a non-conductive filament 8
provided with a conductive coating 9. The material of the non-conductive filament 8 is
preferably, although not necessarily, one of polyester or polyamide. The conductive coating 9
on the other hand is preferably, but not necessarily, a metal coating, formed from for instance
silver.

Although not illustrated, the multifilament core 5 may be twisted. The extent
of the twist should be determined by the properties of the conductive filaments 4 such as
density, thickness of the coating layer 9 and bending/buckling resistance (brittleness).

Fig. 5 shows a conductive yarn 2 according to a second embodiment, which
additionally to a first wrapping yarn 6 has a further wrapping yarn 10 arranged around the
multifilament core 5. The additional wrapping yarn 10 is wound in a second winding
direction B, opposite the first winding direction A of the first wrapping yarn 6, thereby
forming a double spiral structure. The periods of the spirals of the first wrapping yarn 6 and
the additional wrapping yarn 10 may differ from one another. Likewise, other characteristics
may differ, for instance the diameters of the wrapping yarns 6, 10 may vary from one
another, as well as the materials comprised in the wrapping yarns 6, 10, and so on.

In Fig. 6, a conductive yarn 2 according to a third embodiment is shown,
illustrating a net structure wrapping 11 arranged around the multifilament core 5. This
wrapping does not comprise wound wrapping yarns 6, 10 around the core 5 as discussed in
the foregoing with regards to the first and second embodiments, but is rather an open
structured wrapping 11 which likewise enables electrical components to be connected to the
multifilament core 5 while protrusion of worn off filaments 4 through the wrapping is
prevented. The net structure wrapping 11 may for instance be a knitted, open structured
wrapping, adapted for partly enclosing the multifilament core. With the exception of the
formation of the wrapping, the characteristics of the conductive yarn 2 in the third
embodiment are similar to those described in reference to the first and second embodiments.

Fig. 7 is a flow chart illustrating the steps of manufacturing a conductive yarn
2 in accordance with the third embodiment shown in Fig. 6. Accordingly, to manufacture the
electrically conductive yarn 2, a multifilament core 5 comprising a plurality of electrically conductive filaments 4, is, as shown in step 701, provided. Next, the multifilament core 5 is, in step 702, inserted into a preformed wrapping 11 such that the core 5 is partly exposed. Thereby, occurrence of short-circuiting between adjacent electrically conductive yarns 2 is reduced, while electrical connection of electronic components to said multifilament core 5 is enabled. Providing a preformed wrapping 11 may facilitate the manufacturing process, as the preformed wrapping 11 for instance can be thread upon the multifilament core 5 during production of the conductive yarn 2.

The invention has now been discussed in relation to different embodiments. However, it should be appreciated by those skilled in the art that several further alternatives are possible. For example, the features of the different embodiments discussed above may naturally be combined in many other ways.

It will be appreciated by those skilled in the art that several such alternatives similar to those described above could be used without departing from the spirit of the invention, and all such modifications should be regarded as a part of the present invention, as defined in the appended claims.
CLAIMS:

1. An electrically conductive yarn (2) having a multifilament core (5) comprising a plurality of electrically conductive filaments (4), and a wrapping (6, 10) arranged around said multifilament core, characterized in that said wrapping is arranged to partly expose said multifilament core, thereby reducing an occurrence of short-circuiting between adjacent electrically conductive yarns while enabling electrical connection of electronic components to said multifilament core.

2. An electrically conductive yarn according to claim 1, wherein said wrapping is arranged in such a way that a covered portion of an envelope surface (7) of said multifilament core is smaller than an uncovered portion of said envelope surface.

3. An electrically conductive yarn according to claim 1 or 2, wherein said electrically conductive filaments are provided throughout said core, from a center to a perimeter thereof.

4. An electrically conductive yarn according to any one of the preceding claims, wherein each of said electrically conductive filaments comprises a non-conductive filament (8) provided with a conductive coating (9).

5. An electrically conductive yarn according claim 4, wherein said conductive coating is a metal coating.

6. An electrically conductive yarn according to any one of the preceding claims, wherein said wrapping comprises a wrapping yarn (6) which is wound around said multifilament core in a first winding direction (A) to form a single spiral structure.

7. An electrically conductive yarn according to claim 6, wherein a period of said spiral is greater than twice, and smaller than six times a diameter of said wrapping yarn.
8. An electrically conductive yarn according to claim 6 or 7, comprising a further wrapping yarn (10) wound around said multifilament core in a second winding direction (B), opposite said first winding direction, thereby forming a double spiral structure.

9. An electrically conductive yarn according to any one of claims 6 to 8, wherein a diameter of said wrapping yarn is smaller than 75% of a diameter of the multifilament core.

10. An electrically conductive yarn according to any one of claims 1 to 5, wherein said wrapping is arranged to form a net structure (11) around the multifilament core.

11. An electrically conductive yarn according to any one of the preceding claims, wherein said wrapping is electrically conductive.

12. An electrically conductive yarn according to any one of the preceding claims, wherein said wrapping is non-conductive.

13. An electrically conductive yarn according to any one of the preceding claims, wherein said multifilament core is twisted.

14. A method of manufacturing an electrically conductive yarn having a multifilament core comprising a plurality of electrically conductive filaments, comprising the step of:

arranging a wrapping around said multifilament core (step 701, step 702) such that said multifilament core is partly exposed, thereby reducing an occurrence of short-circuiting between adjacent electrically conductive yarns while enabling electrical connection of electronic components to said multifilament core.

15. A method according to claim 14, wherein the step of arranging the wrapping around said multifilament core includes the step of winding a wrapping yarn around said multifilament core in a first winding direction to form a single spiral structure.

16. A method according to claim 15, wherein the step of arranging the wrapping around said multifilament core further includes the step of:

winding a further wrapping yarn around said multifilament core in a second
winding direction, opposite said first winding direction, thereby forming a double spiral structure.

17. A method according to claim 14, wherein the step of arranging the wrapping around said multifilament core includes providing a preformed wrapping around the multifilament core.

18. A fabric (3) for connection of electronic components thereto, comprising a plurality of electrically conductive yarns according to any one of claims 1 to 13.

19. An electronic textile comprising the fabric according to claim 18, comprising at least one electronic component connected thereto.
701 Provide a multifilament core

702 Insert the core into a preformed wrapping

Fig. 7
A. CLASSIFICATION OF SUBJECT MATTER

INV. D02G3/44  D02G3/38

According to International Patent Classification (IPC) or to both national classification and IPC.

B. RELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D02G  D03D  A41D  H05K  D04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**EPO-Internal**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category</th>
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<td>JP 2004 190194 A (IMAI YOSHIO) 8 July 2004 (2004-07-08) the whole document</td>
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Further documents are listed in the continuation of Box C

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- Special categories of cited documents
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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
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