

Electrical connection element

- 5 The invention relates to an electrical connection element comprising an electrical conductor and an electrically conductive coating.

10 Electrical connection elements designed as a flat wire and having a coating of solder are already known.

The known connection element is used to electrically interconnect several electrical components, e.g. solar cells. For this purpose, the connection element is heated and soldered with the
15 electrical component by melting of the coating. Furthermore, coated connection elements designed as punched parts or cut bands are also known.

20 The known connection elements have the disadvantage that considerable energy amounts are required in order to be able to heat the coating fast enough. Otherwise, the coating might not be heated sufficiently quickly so that no reliable connection between electrical conductor and electrical component is obtained.

25 EP 0 668 628 A2 discloses a crimp contact for connecting electrical conductors. The crimp contact consists of a strip of an electrical conductor and is in some areas provided with a layer of soldering material.

30 WO 03/012883 A2 discloses a method for contacting thin-film electrodes by ultrasonic welding using a sonotrode.

US 6 294 255 B1 discloses a method for fixing a flexible electrical conductor in place. In this case, the fixing of the
35 conductor is effected in the region of the contacting spots, which

prevents the forces acting on the conductor from being passed on.

5 EP 1 256 408 A1 discloses a method for soldering flexible electrical conductors by diode laser.

10 The object of the present invention is therefor to provide a connection element of the kind mentioned at the beginning, which is easily machinable and which has a coating that can be heated fast so that a reliable connection between electrical conductor and electrical component can be achieved at higher process speeds.

15 According to the invention, this object is achieved in that the coating is applied in cross-section over the entire circumference of the electrical conductor, and that the surface of the coating at least in some areas is provided with a structuring and/or rough surface.

20 This will give the advantage that an enlarged effective surface of the coating is available compared with an untreated surface and that this therefor has a high optical and/or thermal absorption. In connection with a soldering or bonding process, the required heat can thus be introduced easier and faster. The coating is preferably made of a homogeneous material, into which the structuring and/or rough surface is incorporated by means of a surface treatment. The homogeneity ensures that the entire layer is evenly heated and thus is available for the subsequent bonding process.

30 According to an embodiment of the invention, the electrically conductive coating may contain a solderable material, for example a solder, particularly tin. Thereby, the coating itself can ensure the implementation of a firmly adhering soldered joint in one processing step.

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According to another embodiment, the electrically conductive coating may contain an adhesive, preferably a conductive adhesive. Thereby, the coating may effect the formation of a firmly adhering adhesive bonding.

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Advantageously, the electrical conductor is made of a metal, particularly copper, or a metal alloy, particularly a copper alloy. Thereby, an especially high electric conductivity as well as an easy processability is obtained.

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In a further development of the invention, the structuring and/or rough surface may consist of a knurling or floating. Such a surface modification can for example be made especially easily and automatically by rolling.

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In another embodiment, the structuring and/or rough surface may be made through grinding. Thereby, it will be possible to provide the coating with properties which are independent on the machining direction and thus are the same in all directions on the surface.

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According to another embodiment, the structuring and/or rough surface may be made through etching. A uniform surface modification may likewise be obtained by means of this chemical treatment.

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In a further development, the structuring and/or rough surface may extend in cross-section only across a region of the coating that is intended for energy absorption. Thereby, it is not required to treat the entire surface of the coating. Thus, only the surface region which is later irradiated, for example with infrared light, in connection with the application of the connection element onto the electrical component has to be modified.

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According to another variant, the structuring and/or rough surface may extend in cross-section over the entire circumference

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of the electrical conductor. With this design, it is not necessary when using the connection element according to the invention to pay attention to which part of the coating that is provided with a modified surface. The processing steps are simplified accordingly.

Advantageously, the electrical conductor may be made from a punched part or a cut band. Then, the connection element is specially easy and cost-efficient to produce.

In a preferred embodiment, the electrical conductor may have a length dimension which is large in relation to the cross-section and may for example be designed as a wire. Thereby, it is possible to connect several electrical components to each other via a connection element in one processing step.

Advantageously, a knurling or floating may extend essentially parallel to the longitudinal extension of the electrical conductor. This has the advantage that the floating or knurling easily can be applied in a continuous process during the production of the connection element. In addition, a surface which is uniform over the longitudinal extension and thereby also uniform properties of the coating are obtained in an especially advantageous manner.

In another variant, a grinding direction may extend essentially parallel to the longitudinal extension of the electrical conductor. Also in this case, the surface treatment can be carried out easily in a continuous process. A surface which is uniform over the longitudinal extension and thereby also uniform properties of the coating are likewise obtained.

In a further embodiment, the electrical conductor may be circular in cross-section. Thereby, the use of commercially available wires is possible.

In a particularly preferred embodiment, the electrical conductor may be designed in cross-section with a shape which deviates from the circular shape, for example rectangular, and especially designed as flattened wire. By means of this design, an especially good adherence of the connection element to the electrical component is obtainable owing to the larger contact surface. In addition, the available surface of the coating is enlarged, which allows easier heat entry.

In a further embodiment, the surface of the coating may be provided with a structuring and/or rough surface over the entire length of the connection element. Thereby, an especially high heat entry as well as an especially simple production and processing is possible. The structuring and/or rough surface may be applied in a continuous process during the production, whereas the same properties of the coating are obtained at each place during the processing.

Advantageously, the coating may extend over the entire length of the connection element. It is hereby of advantage that it is not necessary during the processing to pay attention to where the coating is located and where a surface protection for the electrical conductor is obtained through the coating.

In a preferred use, the connection element according to the invention may be applied on a solar cell. A reliable implementation of a connection between the solar cell and the electrical conductor is especially important in this use, and the application of a structuring and/or rough surface in accordance with the invention on the coating is therefore of particular advantage.

In a further embodiment, two or more solar cells may be connected to each other via connection elements according to the invention. Several solar cells may consequently be connected with the connection elements to a larger unit, for example to a

solar module. The module may be encapsulated so as to be weather-proof.

5 The object mentioned at the beginning is also achieved by means of a method for contacting electrical components, in particular solar cells, with the following steps:

- 1) coating an electrical conductor with an electrically conductive coating,
- 10 2) applying a structuring and/or rough surface on the coating,
- 3) applying the thus obtained electrical connection element with the side having the structuring and/or rough surface onto an electrical component, the coating establishing a firm bonding with the electrical conductor and the component.
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Thereby, it is in an advantageous manner possible to obtain an especially quickly implementable connection between the electrical conductor and the electrical component with the employment of comparatively small amounts of energy.

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In a preferred embodiment, an electrical conductor may hereby be used, which has a larger length dimension in comparison to the cross-section and which for example is designed as a wire, preferably as a flattened wire. The electrical conductor may advantageously be applied along its longitudinal extension onto the electrical component. Thereby, it will be possible to connect many electrical components to each other via a connection element in one processing step.

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The invention will be more closely described in an exemplifying manner with reference to the accompanying drawings, in which embodiments are illustrated. It is shown in:

- Fig 1 a first embodiment of a connection element with an electrical conductor with essentially circular cross-section,
- 5 Fig 2 a second embodiment of a connection element with a flat electrical conductor,
- Fig 3 a third embodiment of a connection element with a flat electrical conductor,
- 10 Fig 4 a fourth embodiment of a connection element with a flat electrical conductor,
- 15 Fig 5 the implementation of a bond between an electrical connection element according to the invention and an electrical component,
- 20 Fig 6 a further embodiment, in which the surface of the coating and the surface of the electrical conductor are modified,
- Fig 7 a solar cell with two electrical connection elements applied thereon,
- 25 Fig 8 a solar module consisting of a plurality of solar cells connected to each other by means of electrical connection elements,
- 30 Fig 9 a detail A of the solar module illustrated in Fig 8 with two solar cells interconnected by means of electrical connection elements.

According to a first embodiment, as illustrated in Fig 1, the electrical connection element 1 consists of an electrical conductor 2, which is designed as a core. The electrical conductor 2 is all around provided with a coating 3, which for instance may con-

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tain a solderable material. Alternatively, the coating 3 may also contain an adhesive. The coating 3 has a structured or rough surface 5, which for instance may be formed by rolling, grinding, etching or the like. The effective surface of the coating is therefor larger than the effective surface of such a coating without this processing step.

According to a second embodiment, as illustrated in Fig 2, the electrical connection element 1 consists of an electrical conductor 2 which is designed as a flattened wire. It has a cross-section which is non-circular and essentially rectangular. The upper side of the electrical conductor 2, as illustrated in figures 2a and 2b, is provided with a coating, which likewise is electrically conductive. The upper side of the electrical conductor 2, as illustrated in figures 2a and 2b, i.e. the outside of the coating 3, has a structured or rough surface 5. Alternatively, the lower side of the electrical conductor 2, as illustrated in figures 2a and 2b, may also have a coating.

According to a third embodiment, as illustrated in Fig 3, the electrical connection element 1 consists of an electrical conductor 2 which is designed as a flattened wire similar to the embodiment example according to Fig 2. The coating 3 shown in Fig 3 has on the top side and bottom side of the electrical connection element 1 a structuring and/or rough surface 5. As the coating 3 is also applied in cross-section over the entire circumference of the electrical conductor 2, a universal applicability of the electrical connection element is achieved. During the processing, there is no longer any need to pay attention to the correct position of the electrical connection element 1. In addition, the electrical connection element is protected against harmful environmental influences and corrosion. In this connection, the coating does not have to be of the same thickness everywhere. On the contrary, more coating material may for example be applied on one side. On the opposite side, the layer thickness is for example reduced. In an especially advantageous

manner, the layer thickness on the side intended for contacting is larger than on the opposite side where the coating mainly has a protective function.

- 5 According to a fourth embodiment, as illustrated in Fig 4, the electrical connection element 1 consists of an electrical conductor 2 which is designed as a flattened wire similar to the embodiment examples according to Figs 2 and 3. However, the surface of the coating 3 is here only modified on the side of the electrical conductor 2 intended for energy absorption. The structuring and/or rough surface 5 extends thus in cross-section only across a section of the circumference of the coating. The coating 3 is however in cross-section applied over the entire circumference so that the electrical conductor 2 is completely enveloped by the coating 3. Thereby, the electrical conductor 2 can be protected against environmental influences and corrosion at the same time. Also in this case, the coating does not have to be of the same thickness everywhere. On the contrary, more coating material may for example be applied on one side. On the opposite side, the layer thickness is for example reduced. In an especially advantageous manner, the layer thickness is larger on the side intended for contacting than on the opposite side where the coating mainly has a protective function.
- 25 The use of an electrical connection element according to the invention will in the following be described with reference to Fig 5. In this case, the electrical connection element in Fig 5 has an electrical conductor 2 which is designed as a flattened wire. It is applied on an electrical component 4, for example a solar cell, in such a manner that the coating is disposed with the side having a structuring and/or rough surface 5 in the direction of an energy input device. The energy input device may be any type of device which is capable of sufficiently heating the coating material for the implementation of a reliable connection. Fig 5 shows a connection element where the electrical conductor 2 designed as a flattened wire has a coating all around. As the coating also has

a structuring and/or rough surface 5 on both sides of the connection element 1, the connection element 1 can be applied in the shown position as well as turned in 180°. When the coating 3 consists of a solderable material, the coating is for example heated by infrared light and caused to melt. It will thereby bond to the electrical component 4 and will after cooling ensure a connection between the electrical conductor 2 and the electrical component 4.

- 10 In all embodiments, the surface 5 of the coating 3 may have any kind of structuring, e.g. grooves in longitudinal and/or transverse direction, fluids in longitudinal and/or transverse direction, grinding marks in longitudinal and/or transverse direction, or the like. The rough surface 5 may have one or more preferred directions or may be designed the same in all directions. The structuring and/or rough surface 5 may be implemented mechanically and/or chemically, e.g. by etching.

- 20 In all embodiments, the coating 3 may itself constitute a means for connection of the electrical conductor 2 and the electrical component 4. No further connection means such as for example solder or adhesive is then necessary when using the electrical connection element 1.

- 25 In all embodiments, the coating 3 may consist of a solderable material. The larger surface 5 of the coating 3 enables a quicker heating for the formation of a soldered joint between the electrical conductor 2 and the electrical component 4. Such a soldering may be carried out automatically. The soldering may be executed by means of infrared light. As the coating consists of a solderable material, in particular a solder, e.g. tin, the soldering may be carried out without added material. In this case, the solder necessary for a soldered joint is the coating material itself.

- 35 When the conductive coating 3 according to an alternative contains an adhesive, this can act as a means for connection of

electrical conductor 2 and electrical component 4. Also in this case, an improved energy entry into the coating 3 and thereby a quicker and more reliable implementation of an adhesive bonding between electrical conductor 2 and electrical component 4 is
5 obtained by means of the enlarged surface 5 of the coating 3.

As shown in Fig 6, also the surface 6 of the electrical conductor 2 may be modified in addition to the treatment of the surface 5 of the coating 3. The electrical conductor 2 may thus likewise be
10 designed with a structured and/or rough surface 6. Thereby, the advantage is obtained that an enlarged contact surface between electrical conductor and coating material is available and that the obtainable adhesive strength thereby is increased. The layer thickness of the coating for obtaining a predetermined adhesive
15 strength may at the same time be reduced.

In known electrical connection elements - also in connection elements designed as flattened wire - the coating mostly has a convex surface. With a connection element according to the in-
20 vention, the surface of the coating is however flat and even, due to the treatment of the surface of the coating. The electrical connection element according to the invention can thereby be completely flat and even on its surface, at least in some areas. This has the advantage that it lies flat in connection with the ap-
25 plication onto an electrical component, for example a solar cell, and thereby forms a reliably bonding. When soldered onto a solar cell, in particular onto an imprinted silver bus bar serving as counter contact in the soldered joint, the material lies completely and even, which leads to significantly better soldering results.

30 In addition, such a connection element, for example a flattened wire, which also on its coating has an essentially flat, even surface, is easier to manipulate. In particular the vacuum grippers which are usual for this purpose can grip such even objects
35 more quickly and reliably. In addition, the advantage is obtained that a wire with even, flat surface also can be wound onto a coil

in a more space-saving and faster manner and with enhanced process safety. The wire, in particular when it comes to a flattened wire, is thus easy to wind onto a coil in layers and easy to unwind therefrom. Also the straightness remains ensured, which could be impaired in case of an irregular winding. This constitutes a clear advantage in the machining process with regard to the automation possibility and thereby with regard to the production costs.

The electrical connection element 1 according to the invention may in an especially advantageous manner be used as connector for a solar cell 4. As shown in Fig 7, two connection elements 1, for example designed as flattened wire, are applied onto a surface of the solar cell 4. Alternatively, other described connection elements according to the invention may also be used. When using connection elements with an electrical conductor with likewise structured or rough surface as connector for a solar cell, a high strip-off force or tear-off force is required in order to remove the connection element from the solar cell. It is also possible to reduce the coating thickness for a predetermined strip-off force or tear-off force.

Several solar cells 4 may be connected to each other in any suitable manner into a solar module 7 by means of the connection elements 1. When using connection elements 1 designed as flattened wire, the appearance shown in Fig 8 with continuous connection bands is obtained. Alternatively, other described connection elements according to the invention may also be used, whereby no continuous connection bands are visible when the connection for example is realised using punched parts or cut bands.

A possibility to connect two adjacent solar cells 4 of a solar module 7 is shown in Fig 8. In this case, each top side of a solar cell 4 is connected to the bottom side of an adjacent solar cell 4 by means of connection elements 1 according to the invention.

Further embodiments according to the invention only has a part of the described features and each combination of features, particularly also from different described embodiments, may be contemplated.

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Claims

1. An electrical connection element (1) comprising an electrical conductor (2) and an electrically conductive coating (3), **characterized** in that the coating (3) is applied in cross-section over the entire circumference of the electrical conductor (2), and that the surface of the coating (3) at least in some areas is provided with a structuring and/or rough surface (5).
2. An electrical connection element (1) according to claim 1, **characterized** in that the electrically conductive coating contains a solderable material, for example a solder, particularly tin.
3. An electrical connection element (1) according to claim 1, **characterized** in that the electrically conductive coating contains an adhesive, preferably a conductive adhesive.
4. An electrical connection element (1) according to any of claims 1-3, **characterized** in that the electrical conductor (2) is made of a metal, particularly copper, or a metal alloy, particularly a copper alloy.
5. An electrical connection element (1) according to any of claims 1-4, **characterized** in that the structuring and/or rough surface (5) consists of a knurling of floating.
6. An electrical connection element (1) according to any of claims 1-4, **characterized** in that the structuring and/or rough surface (5) is made by grinding.
7. An electrical connection element (1) according to any of claims 1-4, **characterized** in that the structuring and/or rough surface (5) is made by etching.

- 5 8. An electrical connection element (1) according to any of
claims 1-7, **characterized** in that the structuring and/or
rough surface (5) in cross-section only extends across a
region of the coating (3) that is intended for energy ab-
sorption.
- 10 9. An electrical connection element (1) according to any of
claims 1-7, **characterized** in that the structuring and/or
rough surface (5) in cross-section extends over the entire
circumference of the coating (3).
- 15 10. An electrical connection element (1) according to any of
claims 1-9, **characterized** in that the electrical conductor
(2) is made from a punched part or a cut band.
- 20 11. An electrical connection element (1) according to any of
claims 1-10, **characterized** in that the electrical conductor
(2) has a large length dimension in comparison to the
cross-section and for example is designed as a wire.
- 25 12. An electrical connection element (1) according to claims 6
and 11, **characterized** in that the knurling or floating ex-
tends essentially parallel to the longitudinal extension of
the electrical conductor (2).
- 30 13. An electrical connection element (1) according to claims 7
and 11, **characterized** in that the grinding direction ex-
tends essentially parallel to the longitudinal extension of
the electrical conductor (2).
- 35 14. An electrical connection element (1) according to any of
claims 11-13, **characterized** in that electrical conductor
(2) is circular in cross-section.
15. An electrical connection element (1) according to any of
claims 11-13, **characterized** in that the electrical conduc-

tor (2) has a non-circular shape in cross-section, for example rectangular, and particularly is designed as a flattened wire.

- 5 16. An electrical connection element (1) according to any of claims 11-15, **characterized** in that the surface of the coating (3) is provided with a structuring and/or rough surface (5) along the entire length of the connection element (1).
- 10 17. An electrical connection element (1) according to any of claims 11-16, **characterized** in that the coating (3) extends along the entire length of the connection element (1).
- 15 18. A solar cell (4) on which an electrical connection element (1) according to any of claims 1-17 is applied.
- 20 19. A solar module (7) consisting of two or more solar cells (4), **characterized** in that the solar cells (4) are connected by means of connection elements (1) according to any of claims 1-17.
- 25 20. A method for contacting electrical components, in particular solar cells, characterized by the steps of:
- a) coating an electrical conductor (2) with an electrically conductive coating (3);
 - b) applying a structuring and/or rough surface (5) on the coating (3);
 - 30 c) applying the thus obtained electrical connection element (1) with the side having the structuring and/or rough surface (5) onto an electrical component (4), the coating (3) establishing a firm bonding with the electrical conductor (2) and the component (4).
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21. A method according to claim 20, **characterized** in that the electrical conductor (2) has a large length dimension in comparison to the cross-section and for instance is designed as a wire, preferably a flattened wire, and is applied along its longitudinal extension onto the electrical component (4).