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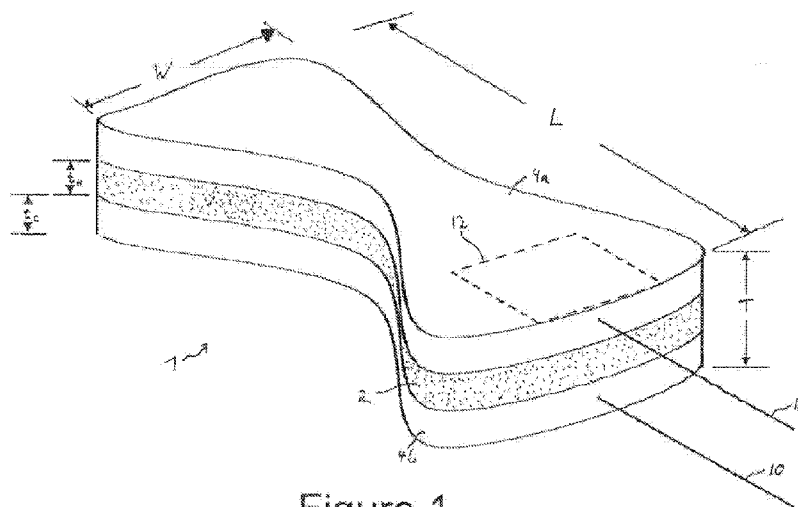


Figure 1

(57) Abstract: Heating device comprising: - a heating foil (1), and - at least one electric wire (10) connecting a conducting layer (4) of the heating foil (1) by means of a punctiform electric contact (11), wherein the heating foil (1) comprises: - a heating layer (2) made of a not compressible polymer with embedded conducting particles (3) that are distributed in the heating layer (2), and - conducting layers (5) disposed on each side of the heating layer (2), wherein at least one of the conducting layers (5) forms a surface electrode.



Heating device and heating foil

The present invention relates to a heating device and a foil.

- 5 Ohmic-resistance heating devices are well known. Especially wire resistance is commonly used. To heat a surface the wire is often disposed on a foil or tape in a side to side and/or zigzag-shaped fashion.

Besides several heating tapes are known, where a flat tape-shaped ohmic-resistor is
10 in contact with electrodes at the edges.

For example, in WO 2017/176208 A self-adhesive heating tape is described that at each edge of a thin conductive carbon ink layer a stripe of conductive paste is disposed. The whole layer is laminated with two insulating polymer layers. The
15 thickness of the heating tape is in the regime of 120 μ m to 300 μ m.

Furthermore, materials with a positive temperature coefficient (PTC materials) are often used for heating devices as well. The advantage of such a material is that point-wise self-regulating and self-limiting devices can be realized. Often ceramics
20 are used as PTC materials. The disadvantage of ceramic lies in the rigid nature of the material.

Recent developments use often silicone rubber as a PTC material. To use the silicone rubber as a heating element the contacting electrodes are placed on one
25 side of the material to ensure the minimal gap between the electrodes, which is needed to ensure the necessary field strength of minimum 30 V/mm. This field strength is necessary to enable the PTC effect in silicone rubber.

For example, in US 9,392,645 B2 a heating element is disclosed having a PTC
30 material. In one embodiment the PTC material is a siloxane elastomer, also known as silicone elastomer, with carbon blacks of PTC type. The PTC layer has a thickness of 10 – 300 μ m is placed on top of an insulating layer. A third layer, which provide the electrode contacts, is placed on top of the PTC layer.

In US 5,250,228 A a conductive polymer composition and an electric device is described. The conductive polymer composition is a mixture of an essentially amorphous thermoplastic resin and a thermosetting resin. The conductive polymer composition can be used e.g. for heaters. In the electric device the conductive
5 polymer composition is placed between two electrodes.

In AT 274965 a method to manufacture silicone rubber with homogeneously distributed, electrically conductive or semiconducting particles is disclosed.

10 In US 4,017,715 A a heater is described, which prevents temperature overshoots. Between two electrodes three layers are disposed. Two layers, those, which are close to the electrodes, are constant wattage layer to prevent an overshoot. A third layer in the middle is a PTC heating layer. The PTC material is, for example, a doped ceramic or a doped thermoplastic polymer.

15 US 4,774,397 A discloses a heater including a substrate, a longitudinal conductor contact portions or stripes and regularly space semiconductor heating portions or bars extending between the stripes.

20 AU 8524575 A, also published as DE 2543907 A1 shows another flexible heater comprising a pair of electrode and sheets of an electrically conductive resistive material as heating layer. This elastic material comprises a mixture of rubber and graphite.

25 Another flexible heating means shown in US 6,172,344 B1 comprises electrodes and a heating layer. The electrodes are positioned at the edges of a thin heating film.

The above mentioned prior art comprises flexible heating tapes, thin heating films and inflexible heating devices.

30 Flexible heating tapes comprise a conductive heating layer and at the edges electrodes so that heating current is applied alongside the heating layer. Such heating tapes are disclosed in WO 2017/176208 A, US 4,774,397 A, AU 8524575 A

and US 6,172,344 B1. These heating tapes are usually cuttable in a direction perpendicular to the edges at which the electrodes are arranged.

Thin heating films comprise a substrate on which a very thin heating film is disposed.

5 On top of the heating film two electrodes are provided. Such thin heating films are shown in US 9,392,645 B2.

These heating devices are very flexible, and the heating material is only cuttable before the electrodes are attached. After the electrodes are placed onto the heating
10 film, the heating device is not cuttable anymore.

Inflexible heating devices comprises at least one hard inflexible layer. They are often using a hard heating layer made of ceramics or thermoplastic. Such inflexible heating devices are described in US 5,250,228 A, US 4,616,125 A and US
15 4,017,715 A. Due to the hard heating material, like ceramic or thermoplastic, the heating device is not flexible and not cuttable.

In US 3,397,302 a flexible sheet-like electric heater for aircraft wings is disclosed. Two thin sheets of electrically conductive metal foil is in on either side of a thin
20 electric resistance layer of polytetrafluoroethylene impregnated with carbon particles. Two current conducting lead wires extend along the entire length of said the sheets.

US 2016/0113065 A1 discloses an electric heater comprising a heating element disposed between a first and a second conductor, wherein the heating element
25 comprises an electric conductive material distributed within an ethylene acetate or ethylene acrylate copolymer, and wherein the heating element has a first thickness in a first region and a different thickness in a second region.

From DE 10 2008 035 057 A1 a fabric is known comprising two main conductors and
30 a plurality of heating conductors. The main conductors are arranged in parallel to each other and along one edge of the fabric. The heating conductors extend also parallel to the main conductors and are distributed over the whole fabric. The heating conductors are connected by means of thin conductive wires with the main conductors so that always certain sections of the heating conductors are supplied

with electricity from the main conductors. This kind of fabric provides a homogenous heating and can be cut freely, wherein the heating function is maintained. However, the main conductors cannot be cut and there is a complex structure of main conductors, heating conductors and conductive wires to achieve the cuttability.

5

The object of the invention is to provide a heating foil, which comprises a simple structure, which is readily manufactured, which is flexible and cuttable without significant geometric limitations and without any special treatment.

10 The above-mentioned object is solved by the subject matter of one of the independent claims. Advantageous developments and preferred embodiments from the subject of the corresponding sub claims.

A heating foil comprises:

15 - a heating layer made of a silicone or polyurethane polymer with embedded conducting particles that are distributed in the heating layer, and
 - conducting layers disposed on each side of the heating layer, wherein at least one of the conducting layers forms a surface electrode.

20 As at least one of the conducting layers forms a surface electrode the current for heating the heating layer is crossing the heating layer from one to the other side, wherein the current is distributed over the area of the surface electrode. This provides a homogeneous heating in this area.

25 Preferably, both conducting layers form a surface electrode.

Furthermore, the conducting layers are preferably opposing each other, wherein also a certain offset is possible.

30 This heating foil comprises a very simple structure as it comprises a heating layer and electrodes, the conducting layers, on both sides of the heating layer.

The heating foil it is preferable flexible. Therefore, the heating foil can adjust to an object, e.g. the sole of a foot, to be comfortable and to heat it efficiently.

The heating layer is preferable not compressible. If the heating layer is pinched, the pressed material of the heating layer will elude. After the heating layer is pinched, the material of the heating layer will recapture its form. This allows to cut the heating foil in the regions where a conducting layer is disposed, because due to the incompressibility of the heating layer the conducting layers are kept apart and do not cause a short circuit.

As long as a sufficient section of the conducting layers is maintained on the heating layer after cutting the heating foil it is possible to use the cut heating layer without the need of applying an electrode to the heating layer as it is needed in the prior art according to US 9,392,645 B2 after cutting the heating layer.

Preferably, the heating layer is completely or nearly completely covered on both sides by the conducting layer. This allows to cut the heating foil in any shape, because then it is secured that the surfaces on each side of the heating layer are sufficiently covered by a conducting layer which forms an electrode.

Completely covered does not mean that the conducting layer has to be a continuous layer without any openings. The conducting layer can be e.g. a mesh or formed with a pattern having one or more openings. The openings shall be so small that a homogeneous current distribution is still possible. The size of the openings is preferably not larger than 10 times of the squared thickness of the heating layer and particularly not larger than 2 times of the squared thickness of the heating layer.

The bulk modulus of the compressibility of silicone is about 1.5 to 2 PGa, which is close to the compressibility of water, which has a bulk modulus of 2.1 to 2.7 PGa. If the heating foil is cut or cropped, e.g. by means of a scissors, the silicone returns to its original position immediately after the clipping, whereby the electrodes remain at a distance from each other. This allows the heating foil to be cropped as desired. The cut edges do not need to be further supported or treated afterwards.

As a further advantage defect areas of the heating foil can be easily cut out without replacing the whole heating foil or treating the cut edges further. The heating foil is

cuttable along a separation area, as long as the separation area is not parallel to one of the layers

Moreover, using an heating layer with embedded conducting particles thick heating layers are feasible, i.e. layers with a thickness of 1 mm and more are achievable, although smaller thickness than 1 mm are possible, too. By using such thick layers made out of silicone or polyurethane the heater will act like a thermic insulator as well.

10 Additionally, due to the flexibility of silicone or polyurethane this thick heating layer will be more comfortable in direct contact with human skin, than for example hard ceramic heating foils.

15 Furthermore, the mechanical properties of silicone change only slightly with temperature changes.

Due to gas permeability of silicone the heating foil is especially suitable for e.g. active winter clothing, active seat heater, or active storage box for food.

20 The heating foil can be perforated so that it is permeable for gas and vapor even if the heating layer is completely covered by the conducting layer or made of a non-permeable polymer. The perforation can be laser cut or punched.

Preferable, the heating layer has a thickness of at least 0.05 mm, 0.1 mm or 0.3 mm.

25 If the heating layer is thin then the electrical resistance is low and the generated heat is accordingly small or there is a significant risk that the heating layer is deteriorated by the heat.

The maximum thickness is preferably not more than 1 mm, particularly not more than 30 2 mm or 10 mm. The electrical resistance is the larger the thicker the layer is.

It is advantageous that the conducting particles are composed of carbon. Carbon is a relatively nonhazardous cheap material, which is easily to fabricate. Carbon can

withstand high temperatures and strong electric currents. The carbon particles can be also carbon nano tubes, carbon black, graphite, or carbon fibers.

Preferably, the conducting particles are homogenously distributed. They can also be
5 randomly distributed.

Favorably, the conducting particles have a concentration in weight relative to the silicone of at least 1%, 10% or 20% and/or preferably not more than 70%, 80% or 95%

10

It is beneficial that the heating layer has specific electrical resistance of minimum 5 Ωm , 10 Ωm or 20 Ωm and maximum 1 $\text{k}\Omega\text{m}$, 10 $\text{k}\Omega\text{m}$ or 100 $\text{k}\Omega\text{m}$

A favorable setting is, that the conducting layer is a metal mesh. The inventors have
15 realized that a non-continuous conducting layer maintains a stronger connection to the silicone layer, if the heating foil is bent. Continuous conducting layer might break or getting more easily detached from the heating layer.

Preferably, the metal mesh consists of conductor stripes or wires with a width or
20 diameter of at least 0.05 mm, 0.1 mm or 0.5 mm and/or preferably not more than 1 mm, 1.5 mm or 2 mm.

The metal mesh can be printed onto the heating layer.

Favorably, the metal mesh has an aperture with a maximum diameter of at least 0.05
25 mm, 0.5 mm or 1 mm and/or preferably not more than 5 mm, 10 mm or 15 mm. The apertures can be in the form of a circle or any other form. If the aperture deviates from the form of the circle then it comprises different diameters.

It is advantageous, that the conducting layers are covered with an insulator layer,
30 which isolates the heating foil electronically and/or thermally. Therefore, the heating foil can be touched without risking an electric shock. Furthermore, the insulator layer, made out of e.g. a polymer, protects the other layer from harm like e.g. sharp objects or liquids. Additionally, using a thermally isolation will direct the heating to one side mainly. This is beneficially in clothing. On the side towards a human body is needed

to be heated. The other side can be insulated, which will increase the heating on the preferred side.

Preferably, on both sides of the heating foil an electrical insulator is provided.

5

It is advantageous, that on one side of the heating foil a thermally insulator is provided.

10

There can be an insulator structure comprising several insulating layers. It can also make sense to provide on one side of the heating foil an insulating layer which forms a good electrically and thermally insulator and on the other side an insulating layer which forms a good electrically but not so good thermally insulator. This can be e.g. achieved by applying on one side a thick layer of insulating material and on the other side a thin layer of insulating material of the same or different insulating material.

15

The concentration of the embedded conducting particles may be heterogeneous. A heterogeneous concentration is defined as a certain concentration of embedded conducting particles at a certain area and another concentration of embedded conducting particles at another, different area. The change of the concentration between these areas may be continuous. This will result in different heating areas of heating. For example, an area with higher concentration will results in a higher temperature.

20

An area with a certain concentration might follow a specific shape.

25

The heating foil can comprise several separated conducting areas in the heating layer, wherein the non-conducting areas in between the separated conducting areas are embodied so that they do not conduct significant amounts of electrical current and do therefore not contribute to the heating of the heating foil. The conducting areas can be composed of silicone with embedded conducting particles and the non-conducting areas can be composed of a polymer without embedded conducting particles.

30

The conducting areas can be defined by the shape of the conducting layer and the non-conducting areas can be defined by omitting the conducting layers in these

areas. Each segment of the conduction layer in a certain conducting area shall to be in electrically contact with the other segments of the conducting layer. These electrical connections can be e.g. embodied by thin conducting paths of the conducting layer in between the individual segments.

5

With this separation in conducting areas and non-conducting areas it is possible to use large heating foils which have e.g. a size of one or more m². Even with such a size a reasonable power consumption can be achieved. Large heating foils with one single continuous heating area would need a conducting layer with a very small electric resistance due to the large size of the heating layer. This makes it difficult to control the electrical power and thus the heating behavior of the heating foil. If a plurality of heating areas are provided a homogeneous temperature distribution can be easily achieved, particularly if the conducting layer is completely covering the heating layer, because electrically conducting materials are mostly also good heat conductors.

10

15

For example, the conducting area can be shaped like circles in the plain view.

Preferably, the conducting areas are equally distributed.

20

A heating device comprising:

- a heating foil, and
- at least one electric wire connecting a conducting layer of the heating foil by means of a punctiform electric contact,

25

wherein the heating foil comprises:

- a heating layer made of a not compressible polymer with embedded conducting particles that are distributed in the heating layer, and
- conducting layers disposed on each side of the heating layer, wherein at least one of the conducting layers forms a surface electrode.

30

The electric wire can be used to connect the heating device to an electric circuit.

The punctiform electric contact is, for example, a soldering point. Punctiform means that the area of the electric contact is significantly smaller than the area of the conductive area.

The heating foil can be cut everywhere, as long as the conducting layers of the remaining areas have a punctiform electric contact.

Preferably, the heating foil corresponds to the above mentioned heating foil.

5

Subsequently, exemplarily two embodiments of the invention will be described by reference to the illustrations.

The illustrations show schematically in:

- 10 Figure 1 an embodiment of the inventive heating device in isometric view,
- Figure 2 a section 12 of the heating device in Fig. 1,
- Figure 3 the section 12 of the heating device of Fig. 2 with cut layers,
- Figure 4 an alternative of a section of the heating device of Fig. 1,
- Figure 5 a second embodiment of the inventive heating device with separated
- 15 conducting areas in shown with cut layers,
- Figure 6 a section of a heating device with insulating layers, and
- Figure 7 an implementation in an electric circuit of the inventive heating device in isometric view.

- 20 A heating device for a heating shoe forms a first exemplary embodiment of the present invention (figure 1 to 4).

The heating device comprises a heating foil 1 and at least one electric wire 10 connecting the heating foil 1 by means of a punctiform electric contact 11 to an

25 electric circuit 9.

The heating foil 1 is a flexible sheet, i.e. width W and length L is larger than thickness T . In this embodiment the shape of the inventive heating foil follows the shape of the shoe in plain view with a maximum width $W = 10$ cm and the length L is

30 25 cm. The area A of the heating foil 1 in plain view is about 200 cm^2 .

This heating foil 1 comprises a heating layer 2 with embedded conducting particles 3 for heating, two cover layers 4a and 4b to cover the heating layer 2.

The cover layer 4 comprise a conducting layer 5 to connect the heating foil 1 to an external electric circuit 9 and an insulating layer 6.

Alternatively, the cover layer 4 comprise only a conducting layer 5.

5

The external electric circuit 9 is connected to the conducting layers 5a and 5b by the electric wire 10. The contact between the external electric circuit 9 and one of the conducting layers 5 is a punctiform electric contact 11, which comprises for example, a soldering point.

10

The heating layer 2 is placed between the two conducting layers 5a and 5b and has in this embodiment a thickness t_H of 1 mm. The specific electric resistance ρ is 240 Ωm . With a specific electric resistance $\rho = 240 \Omega\text{m}$ the total electric resistance R can be calculated:

15

$$R = \rho \cdot t_H / A = 12 \Omega.$$

In this embodiment the material of the embedded conducting particles 3 is carbon. The carbon concentration in weight relative to the silicone of resistance of 4%. The size of on carbon particle 3 is between 0.1 μm and 100 μm .

20

In this embodiment the conducting layers 5a and 5b consist of a woven metallic mash, which comprises wires with a diameter of 0.1 mm and has an aperture with a maximum diameter of about 1 mm. The conducting layers 5a and 5b are attached to the silicon layer, e.g. by gluing (with conductive glue) or melting.

25

The insulating layers 6a and 6b covers each conducting layer 5a and 5b and are attached to them. The insulating layer 6a is the layer on the top side, which is close to the human body (foot). It is an electrically insulator to prevent the human from an electric shock. The material of the insulation layer 6a is in this embodiment Polyethylenterephthalat (PET). The thickness of this insulating layer 6a is about 0.1 mm.

30

The insulating layer 6b is attached to the downside of the heating foil 1. It is insulating electrically and thermally. Therefore, the heating is directed towards the human body. The material of the insulation layer 6b is in this embodiment PET. The thickness of this insulating layer 6b is about 2 mm.

5

Hereinafter, the use of an inventive heating foil is described (figure 6).

In this embodiment a heating power of 12 W is desired, which is a reasonable value for a heating shoe sheet. In other embodiments other heating power are feasible.

10

To create heat the heating foil is connected at the conducting layers 5a and 5b to an electric circuit 9. In this embodiment of a heating shoe sheet the electric circuit 9 has a voltage supply of 12 V. In other embodiments other voltages are feasible.

15

With a given resistance $R = 12 \Omega$ of the heating layer 2, the current can be calculated:

$$I = U / R = 12 \text{ V} / 12 \Omega = 1 \text{ A}.$$

20

Therefore, the power P is:

$$P = U \cdot I = 12 \text{ V} \cdot 1 \text{ A} = 12 \text{ W}.$$

The resulting power P corresponds to the desired 12 W.

25

Hereinafter, a second embodiment of the invention is described, wherein same elements are provided with the same reference numbers as in the first embodiment. The above description applies to the same elements unless otherwise stated below (Fig. 1 and 5).

30

Again, a heating device comprises a heating foil 1 and at least one electric wire 10 connecting the heating foil 1 by means of a punctiform electric contact 11 to an electric circuit 9.

The heating foil is a flexible sheet, i.e. width W and length L is larger than thickness T . In this embodiment the shape of the inventive heating foil follows the shape of the shoe in plain view with a maximum width $W = 10$ cm and the length L is 25 cm. The area A of the heating foil 1 in plain view is about 200 cm².

5

This heating foil 1 comprises a heating layer 2 with embedded conducting particles 3 for heating, two cover layers 4a and 4b to cover the heating layer 2.

10

The cover layer 4 comprise a conducting layer 5 to connect the heating foil 1 to an external electric circuit 9 and an insulating layer 6.

Alternatively, the cover layer 4 comprise only a conducting layer 5.

15

The external electric circuit 9 is connected to the conducting layers 5a and 5b by an electric wire 10. The contact between the external electric circuit 9 and one of the conducting layers 5 is a punctiform electric contact 11, which comprises for example, a soldering point.

20

The heating layer 2 is placed between the two conducting layers 5a and 5b and has in this embodiment a thickness t_H of 1 mm.

25

Unlike the first embodiment, the heating layer 2 consist of two different areas: conducting areas 7 for heating, which are embedded in a non-conducting area 8. Both areas are made out of silicone, while the conducting areas 7 comprises embedded conducting particles 3 and the non-conducting area 8 are mostly free of embedded conducting particles 3. Each area is connected to both conducting layers 5a and 5b.

30

The non-conducting area 8 is spread over the whole heating layer, while the conducting area 7 are equally distributed.

In this embodiment, the conducting area 7 are circle shaped in plain view. The thickness t_H is 1 mm. One circle plane has a radius of 0.56 mm. The area of the circle is 1 mm². The volume of the cylinder is therefore 1 mm³.

In this embodiment the total number of conducting areas 7 are 1600, which results in a circle density of 2 per 25 mm² at the connection of the heating layer 2 to one of the conducting layers 5a and 5b. The total volume of the conducting area 7 is 1700 mm³

5 The total area A_{Circle} is 1700 mm²

The specific electric resistance ρ is here 20.4 Ωm . With a specific electric resistance $\rho = 20.4 \Omega\text{m}$ the total electric resistance R can be calculated:

10
$$R = \rho \cdot t_H / A_{\text{Circle}} = 12 \Omega.$$

In this embodiment the material of the embedded conducting particles 3 is carbon. The carbon concentration in weight relative to the silicone of resistance of 6%. The size of on carbon particle 3 is between 0.1 μm and 100 μm .

15

In this embodiment the conducting layers 5a and 5b consist of a woven metallic mesh 5, which consist of wires with a diameter of 0.1 mm and has an aperture with a maximum diameter of about 1 mm. The conducting layers 5a and 5b are attached to the silicon layer, e.g. by gluing (with conductive glue) or melting.

20

The insulating layers 6a and 6b covers each conducting layer 5a and 5b and are attached to them. The insulating layer 6a is the layer on the top side, which is close to the human body (foot). It is only an electrically insulator to prevent the human from an electric shock. The material of the insulation layer 6a is in this embodiment

25 Polyethylenterephthalat (PET). The thickness of this insulating layer 6a is about 0.1 mm.

The insulating layer 6b is attached to the downside of the heating foil 1. It is insulating electrically and thermally. Therefore, the heating is directed towards the human body. The material of the insulation layer 6b is in this embodiment PET. The thickness of this insulating layer 6b is about 2 mm.

30

Hereinafter, the use of an inventive heating foil is described (figure 6).

In this embodiment a heating power of 12 W is desired, which is a reasonable value for a heating shoe sheet. In other embodiments other heating power are feasible.

To create heat the heating foil is connected at the conducting layers to an electric circuit 9. In this embodiment of a heating shoe sheet the electric circuit 9 has a voltage supply of 12 V. In other embodiments other voltages are feasible.

With a given resistance $R = 12 \Omega$ of the heating layer 2, the current can be calculated:

10

$$I = U / R = 12 \text{ V} / 12 \Omega = 1 \text{ A}.$$

Therefore, the power P is:

15

$$P = U \cdot I = 12 \text{ V} \cdot 1 \text{ A} = 12 \text{ W}.$$

The resulting power P corresponds to the desired 12 W.

In an alternative embodiment the conducting areas 7 can be defined by the shape of the conducting layer 5 and the non-conducting areas 8 can be defined by omitting the conducting layers 5a and 5b in these areas. Each segment of the conduction layer 5 in a certain conducting area is in electrically contact with the other segments of the conducting layer 7. These electrical connections can be e.g. embodied by thin conducting paths of the conducting layer 7 in between the individual segments. For example, small electrode dots can be glued on each side of the heating layer 2. Afterwards they are connected via small wires, which can be performed by bonding machines.

To stabilize this arrangement of electrode dots and bonding wires, the insulating layer 6 can be attached in liquid form on each side. This will fix the arrangement and isolate the electric circuit 9 at the same time.

Beneficially, the temperature can be adjusted by a control unit, which control the electric power by adjusting the voltage and/or the current. By changing the power, the final temperature will change as well.

- 5 In an alternative embodiment, the conducting layer 5 is applied on the heating layer 2 with a material sputter device, similar to e.g. metallized boPET films. This will result in a thin conducting layer 5 with a very high flexibility and strong connection to the heating layer.
- 10 Alternatively, instead of a single heating layer 2 in between two conducting layers 5a and 5b, it might be advantageously to stack several heating 2 and conducting layers 5a and 5b alternatingly.

- Beneficially, the heating layer 2 is transparent by using e.g. transparent silicone. The
15 embedded conducting particles 3 might tarnish the heating layer 2, but nevertheless light will be go through the layer. In combination with a metal mesh 5, a translucent heating foil 1 is feasible.

- In an alternative embodiment the heating foil 1 is controlled with a sensor. One
20 option is to measure the current, which flows through the heating foil, as long as the power supply is a voltage supply. Although the heating layer has a low temperature dependence, this dependence can be used to determine the temperature. Similarly, the temperature depending resistance can be measured using a four-point-measurement. Alternatively, a temperature sensor can be attached to the heating foil
25 1 directly. A control unit can adjust the power due to the measured temperature and the desired temperature.

- Alternatively, the concentration of embedded conducting particles 3 in the heating layer 2 can vary. This will result in different heating areas of heating. For example,
30 the form of the area with higher concentration, which results a higher temperature, might follow a specific shape.

In an alternative embodiment the variation of concentration between two areas of the heating layer 2 change continuously. For example, the concentration might follow a linear, squared or exponential local dependence.

- 5 In an alternative embodiment the thickness of the heating layer t_H can vary. This will result in different heating areas of heating.

List of reference numbers

- 1 Heating foil
- 2 heating layer
- 3 embedded conducting particles
- 4 cover layer
- 5 conducting layer
- 6 insulator layer
- 7 conducting area
- 8 non-conducting area
- 9 electric circuit
- 10 electric wire
- 11 punctiform electric contact
- 12 section of heating foil

- ρ specific electric resistance
- R total electric resistance
- I current
- V voltage
- P power
- W width
- L length
- T thickness of heating foil
- t_H thickness of heating layer
- t_C thickness of conducting layer
- A plane area

Claims

1. Heating foil (1) comprising:
 - a heating layer (2) made of silicone or polyurethane polymer with embedded conducting particles (3) that are distributed in the heating layer (2), and
 - conducting layers (5) disposed on each side of the heating layer (2), wherein at least one of the conducting layers (5) forms a surface electrode.
2. Heating foil (1) according to claim 1, characterized in that the conducting particles (3) are composed of carbon, carbon black, graphite, carbon fibres or carbon nano tubes.
3. Heating foil (1) according to claim 1 or 2, characterized in that the conducting particles (3) has a concentration in weight relative to the not compressible polymer of resistance of at least 1%, 10% or 20% and/or preferably not more than 70%, 80% or 95%.
4. Heating foil (1) according to one of the claims 1 to 3, characterized in that the heating layer (2) has specific electrical resistance of at least 5 Ωm , 10 Ωm or 20 Ωm and/or preferably not more than 1 $\text{k}\Omega\text{m}$, 10 $\text{k}\Omega\text{m}$ or 100 $\text{k}\Omega\text{m}$.
5. Heating foil (1) according to one of the claims 1 to 4, characterized in that the conducting layer (5) is a metal mesh.
6. Heating foil (1) according to claim 5, characterized in that the metal mesh consists of wires with a diameter of at least 0.05 mm, 0.1 mm or 0.5 mm and/or preferably not more than 1 mm, 1.5 mm or 2 mm.

7. Heating foil (1) according to claim 5 or 6,
characterized in that
the metal mesh (5) has an aperture with a maximum diameter of at least 0.05 mm, 0.5 mm or 1 mm and/or preferably not more than 5 mm, 10 mm or 15 mm.
8. Heating foil (1) according to one of the claims 1 to 7,
characterized in that
the conducting layers (4) are covered with an additional insulator layer (6),
which insulated the heating electronically and/or thermally.
9. Heating foil (1) according to one of the claims 1 to 8,
characterized in that
the concentration of the embedded conducting particles (3) is heterogeneous.
10. Heating foil (1) according to one of the claims 1 to 9,
characterized in that
several separated conducting areas (7) of the heating layer (2) are comprised,
wherein non-conducting (8) of the heating layer (2) areas in between the
separated conducting areas (7) are embodied so that they do not conduct
significant amounts of electrical current and do therefore not contribute to the
heating of the heating foil (1).
11. Heating foil (1) according to claim 10,
characterized in that
the conducting areas (7) can be composed of silicone with embedded
conducting particles (3) and the non-conducting areas (8) can be composed of a
polymer without embedded conducting particles (3).
12. Heating foil (1) according to claim 10 or 11,
characterized in that
the conducting areas (7) can be defined by the shape of the conducting layer (5)
and the non-conducting areas (8) can be defined by omitting the conducting
layers (5) in these areas.

13. Heating device comprising:

- a heating foil (1), and
- at least one electric wire (10) connecting a conducting layer (5) of the heating foil (1) by means of a punctiform electric contact (11),

wherein the heating foil (1) comprises:

- a heating layer (2) made of a not compressible polymer with embedded conducting particles (3) that are distributed in the heating layer (2), and
- conducting layers (5) disposed on each side of the heating layer (2), wherein at least one of the conducting layers (5) forms a surface electrode.

14. Heating device according to claim 13,

characterized in that

the heating foil (1) correspond to one of the claims 1 to 12.

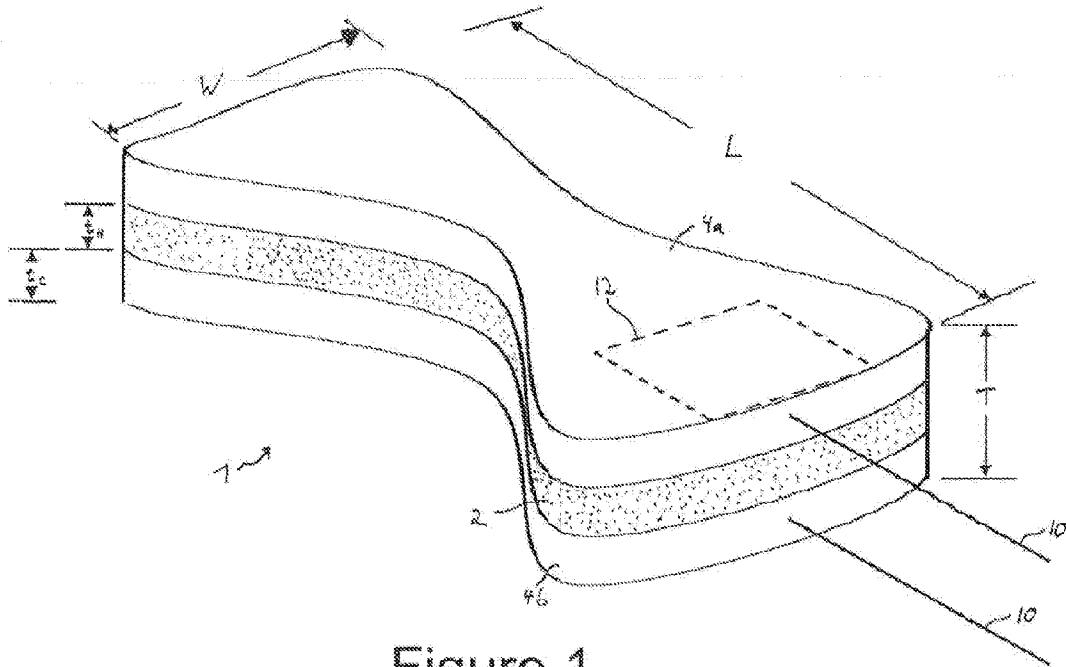


Figure 1

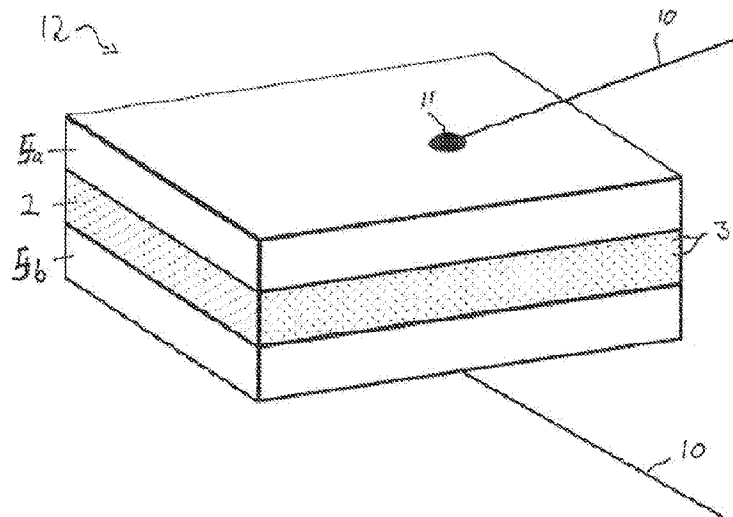


Figure 2

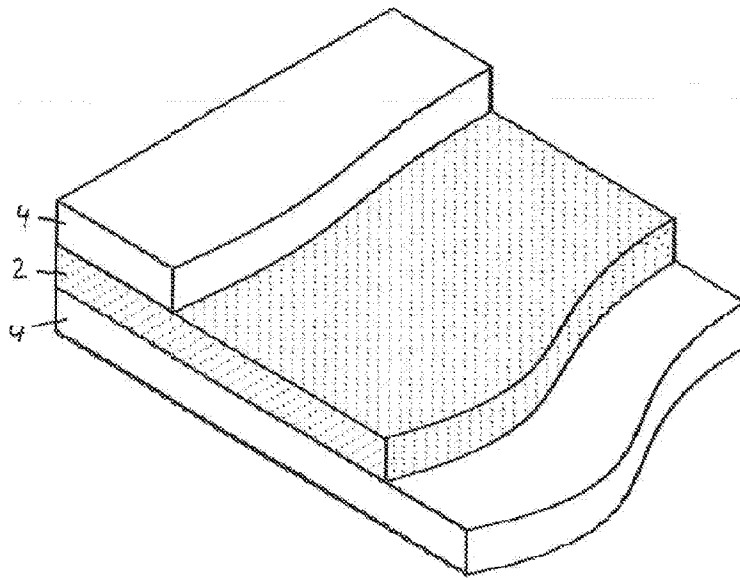


Figure 3

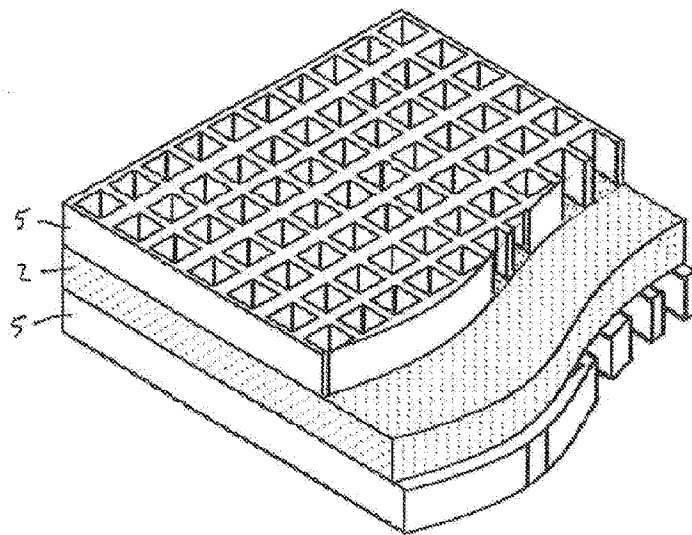


Figure 4

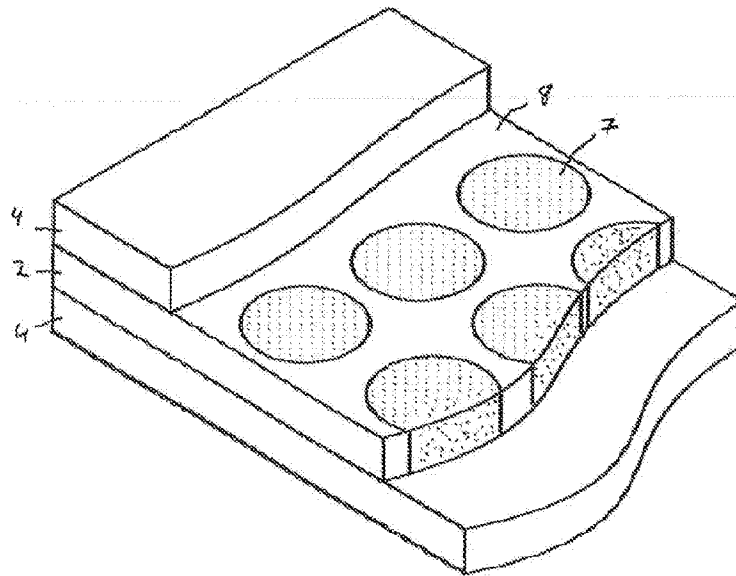


Figure 5

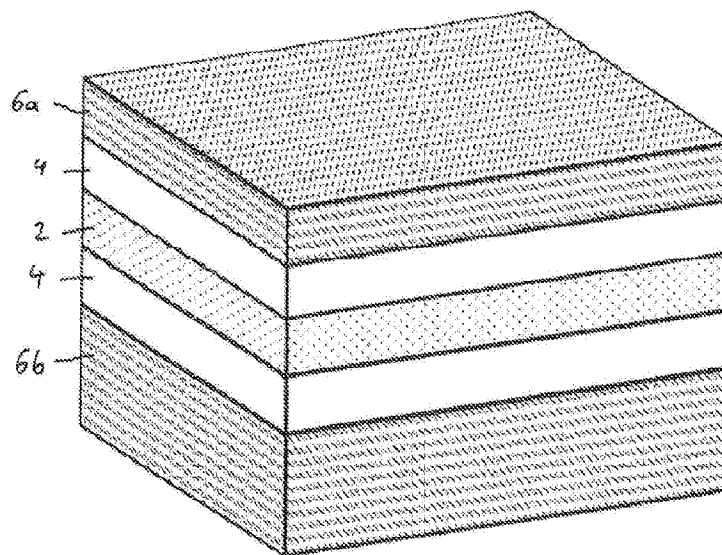


Figure 6

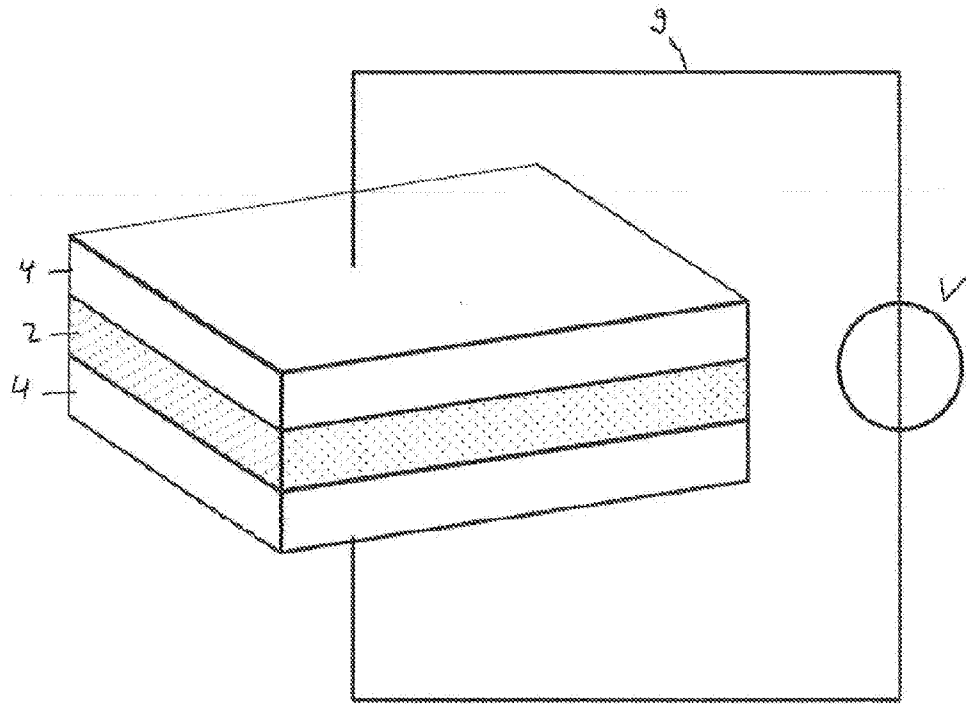


Figure 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SG2018/050306

A. CLASSIFICATION OF SUBJECT MATTER**H05B 3/38 (2006.01)** F24D 13/02 (2006.01) H05B 3/14 (2006.01) H05B 3/18 (2006.01)

According to International Patent Classification (IPC)

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B32B; F24D13/00; H05B 3/00

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 practicable, search terms used)

FAMPAT: Heating foil, silicone, polyurethane, polymer embedded with conducting particles, surface electrode, 加热箔, 聚合物, 导电粒子, 表面电极, and related terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/0320191 A1 (VON WACHENFELDT F. ET AL.) 23 December 2010 Paragraphs [0024]-[0026], [0054], [0068], [0076], [0083]; Figure 1; Examples	1-14
X	US 4833305 A (MASHIMO S. ET AL.) 23 May 1989 Column 2 Lines 5-6, Column 5 Lines 1-54, Column 8 Line 59; Figures 9, 11; Table 2; Example 2-4	1-14
A	US 2006/0000823 A1 (TRUCKAI C. ET AL.) 5 January 2006 Paragraphs [0075]-[0080]; Examples	
A	US 4743321 A (SONI P. L. ET AL.) 10 May 1988 Figures 1, 2; Examples	
A	US 4783587 A (ISHII K. ET AL.) 8 November 1988 Column 2 Line 63-Column 3 Line 10; Figures 1-7	

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.***Special categories of cited documents:**

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

30/08/2018

(day/month/year)

Date of mailing of the international search report

05/09/2018

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SG2018/050306**C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 103572453 A (TAEGUN SOLUTECH) 12 February 2014 Paragraphs [0021], [0022] of the machine translation	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SG2018/050306

Note: This Annex lists known patent family members relating to the patent documents cited in this International Search Report. This Authority is in no way liable for these particulars which are merely given for the purpose of information.

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US 4743321 A	10/05/1988	JP S6293902 A AU 6350686 A CA 1262467 A DK 473086 A BR 8604825 A NO 863915 A ZA 8607571 B EP 0220003 A2 NZ 217791 A	30/04/1987 09/04/1987 24/10/1989 05/04/1987 17/11/1987 06/04/1987 24/06/1987 29/04/1987 29/11/1988
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CN 103572453 A	12/02/2014	NONE	