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(54) **METHOD FOR PRODUCING A HEATING MAT AND HEATING MAT**

(57) The present invention is directed to a Method for producing a heating mat for a vehicle component, comprising the steps of:

providing a flexible, porous carrier layer (2),
connecting a heating conductor (4) to the carrier layer (2) to extend along the carrier layer in a predetermined pattern, and
fixing a temperature sensor (6) on the carrier layer (2) at a predetermined position and providing electric connections (8) to the temperature sensor for sensing a signal indicative of the temperature of the temperature sensor, characterized in that the temperature sensor (6) is fixed on the carrier layer by depositing temperature sensitive material having a temperature dependent resistivity on the carrier layer (2) in a spatially selective manner to form a conductor path of predefined dimensions and at least partially penetrating the carrier layer (2).

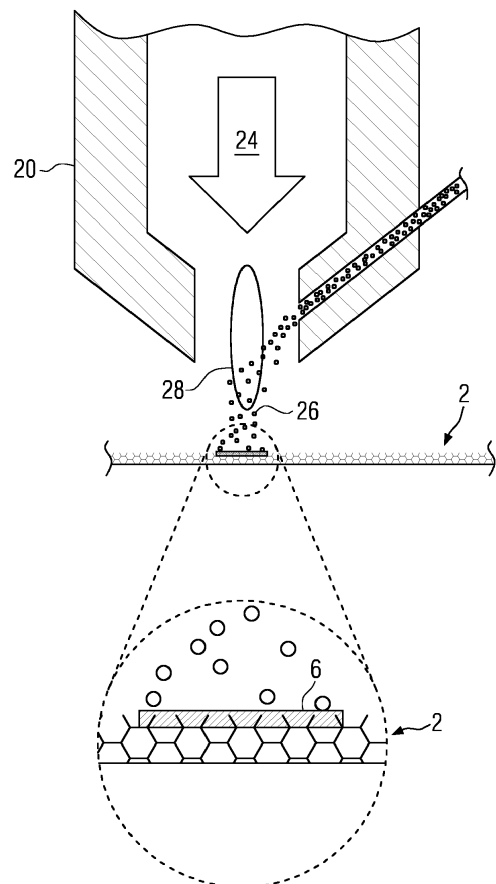


FIG. 3

Description

[0001] The present invention relates to a method for producing a heating mat for a vehicle component, comprising the steps of:

providing a flexible, porous carrier layer,

connecting a heating conductor to the carrier layer to extend along the carrier layer in a predetermined pattern, and

fixing a temperature sensor on the carrier layer at a predetermined position and providing electric connections to the temperature sensor for sensing a signal indicative of the temperature of the temperature sensor.

[0002] A method as described above and a corresponding heating mat are for example disclosed in WO 02/06083 A1. In this document a vehicle seat heating is disclosed comprising a heating mat to be placed between a seat cushion body and a seat cover. The heating mat comprises a flexible and porous carrier layer which typically consists of a layer of textile material, for example a fabric or non-woven fleece layer, or an open-cell foam material. A heating conductor in the form of a conducting wire is placed on the carrier layer to extend along the carrier layer in a predetermined pattern, for example in a meander pattern. The conducting wire is fixed to the carrier layer, for example by stitching, to maintain the positioning of the heating conductor. Other examples of vehicle components which are equipped with heating mats are arm rests or steering wheels. In case of a steering wheel the heating mat is wrapped around a wheel body and surrounded by a cover of lather, artificial lather or plastics.

[0003] In order to allow adjustment of the heating temperature a temperature sensor is provided on the heating mat which is connected to a control unit. The control unit also controls the power supply to the heating conductor by utilizing a control loop with input from the temperature sensor to set the power supply to the heating conductor such that the temperature sensed by the temperature sensor is maintained at an adjusted temperature. The temperature sensor in many cases is a thermistor of the NTC kind ("negative temperature coefficient") or of the PTC kind ("positive temperature coefficient") having a temperature dependent resistivity. The temperature sensing materials used have a strong dependence of the resistivity on the temperature such that small changes in temperature result in large changes of the resistance of the temperature sensor, either with a negative or positive temperature coefficient as indicated above. The resistance of the temperature sensor is sensed by the control unit to determine the temperature in the area where the temperature sensor is located. In traditional methods of making such heating mats the temperature sensor is

fixed on the heating mat at a predetermined position with respect to the heating conductor. The fixation of the temperature sensor on the carrier layer has to be permanent such that the positioning of the temperature sensor with respect to the heating conductor which is likewise fixed to the carrier layer is maintained permanently. This fixed positioning of the temperature sensor on the carrier layer with respect to the heating conductor is important because any changes in the positioning with respect to the heating conductor would result in changing sensed temperatures, and would thus make the temperature measurement unreliable.

[0004] In traditional methods of making heating mats the carrier layers with positioning marks indicating the position on the carrier layer where the temperature sensor had to be fixed. The temperature sensor was then manually fixed at this position, for example by stitching or glueing it to the carrier layer. This step of fixing the temperature sensor to the carrier layer had to be performed manually and with high precision which made the overall process of producing the heating mats personnel and time-consuming.

[0005] It is an object of the present invention to improve a method of producing heating mats for vehicle components such that it can be performed in a more automated and less time-consuming manner, and to define a heating mat with an improved fixation of the temperature sensor on the carrier layer.

[0006] These objects are achieved by the method of claim 1 and by the heating mat of claim 7. Preferred embodiments of the invention are set out in the dependent claims.

[0007] According to the present invention the temperature sensor is formed and fixed to the carrier layer by depositing temperature sensitive material having a temperature dependent resistivity on the carrier layer. This deposition of the temperature sensitive material takes place at a predetermined position and in a spatially selective manner to form a conductor path of the temperature sensitive material as a temperature sensor, wherein the conductor path has predefined dimensions and is deposited on the carrier layer in such a manner such that the temperature sensitive material is at least partially penetrating the carrier layer.

[0008] The spatially selective deposition of the temperature sensitive material is a printing process transferring temperature sensitive material onto the carrier layer. Such spatially selective deposition or printing of the material allows to precisely control the positioning and the dimensions of the conductor path printed. Such deposition or printing process can be performed utilizing printing heads which can be positioned and moved under control of a control unit which permits to form the temperature sensor on the carrier layer in an automated, precise and fast manner.

[0009] When the temperature sensitive material is deposited or printed on the carrier layer it has properties of a liquid and is thus drawn into the pores of the carrier

layer, thereby penetrates the carrier layer at least partially, i.e. up to a certain depth below the surface, and filling the pores, before the temperature sensitive material solidifies.

[0010] In a preferred embodiment the deposition of temperature sensitive material with at least partial penetration of the carrier layer is performed by depositing temperature sensitive material which is, at least at the time of deposition, in a flowable state. In this way the temperature sensitive material when contacting the carrier layer surface enters and fills pores in the carrier layer structure and thereby permeates into the carrier layer to a certain depth. When the deposited temperature sensitive material solidified after deposition the interface region of the carrier layer into which the temperature sensitive material permeated is embedded by temperature sensitive material which results in an intimate connection of the carrier layer with the conductor path of temperature sensitive material.

[0011] In a preferred embodiment the temperature sensitive material is deposited on the carrier layer by plasma spraying the temperature sensitive conductor material onto the carrier layer. Plasma spraying is a thermal spraying process in which melted material is sprayed onto a surface to provide a coating. The material to be sprayed is provided as powder and is injected into a plasma flame where it is rapidly heated and accelerated to a high velocity. The hot material impacts on the receptor surface and rapidly cools, thereby forming a coating, partially extending into and embedding carrier layer structure elements (e.g. fibres). A plasma spray gun comprises an anode (e.g. made of copper) and a cathode (e.g. made of tungsten), both of which are water cooled. Plasma gas (argon, nitrogen, hydrogen, helium, or air) flows around the cathode and through the anode which is shaped as a constricting nozzle. The plasma is initiated by a high voltage discharge which causes localized ionisation and a conductive path for a DC arc to form between cathode and anode. The resistance heating from the arc causes the gas to reach high temperatures, dissociate and ionize to form a plasma. The plasma exits the anode nozzle as a free or neutral plasma flame. When the plasma is stabilized ready for spraying the electric arc extends down the nozzle, instead of shorting out to the nearest edge of the anode nozzle. This stretching of the arc is a thermal pinch effect. Cold gas around the surface of a water cooled anode nozzle being electrically non-conductive constricts the plasma arc, raising its temperature and velocity. Powder of the material to be sprayed is fed into the plasma flame via an external powder port mounted near the anode nozzle exit. The powder injected into the plasma flame is rapidly heated and accelerated and directed onto the target surface.

[0012] It is particularly preferred that the plasma spraying is performed as "cold plasma spraying" to deposit the temperature sensitive material. With cold plasma spraying, powder of micro particles, usually smaller than 20 μm are melted using plasma in a plasma jet and sprayed

onto the carrier layer. Using particularly small particles allows melting to be carried out at comparatively low temperatures. This makes it possible to deposit coatings on carrier layer materials that are sensitive to temperatures such as many fabrics, non-woven textiles and open-celled foams are. A wide variety of materials can be deposited by cold plasma spraying such as metals, metal-oxides, semiconductors, and plastics.

[0013] Advantages of the cold plasma spraying for the deposition process are that there is no need for binders, no need for wet-chemical process steps, no need for additional tools, and no need for a pre-treatment of the carrier layer onto which the conductor path is to be deposited by cold plasma spraying.

[0014] However, in other preferred embodiments the step of depositing the temperature sensitive material on the carrier layer to form the conductor path can be carried out by any other printing process, such as ink-jet printing or screen printing. There are for example conductive, temperature sensitive inks which can be printed using conventional inkjet printheads, wherein the deposited or printed ink solidifies after deposition on the carrier layer by evaporation of solvents. Such inks can be slurries comprising a liquid binder and a particulate filler material, the particulate filler material being a powder of temperature sensitive material dispersed in the binder. The binder can be a vaporizable solvent. The solvent evaporates after the printing of the temperature sensitive conductor path, thereby solidifying the conductor path.

[0015] There are other printable materials with temperature sensitive conductive fillers which solidify after deposition, for example by polymerization.

[0016] Also, by using printheads the process of depositing a conductor path of temperature sensitive material as temperature sensor can be carried out under computer control in a highly automated manner. Furthermore, a printhead may be provided with a sensor for detecting the presence of the heating conductor on the carrier layer. When performing the printing process the sensor is moved together with the printhead relative to the carrier layer and the heating conductor thereon, thus allowing to precisely control the position of the printed temperature sensitive conductor path relative to the heating conductor on the carrier layer.

[0017] In a preferred embodiment the electric connections which are needed for sensing the temperature dependent resistance of the conductor path of the temperature sensor are formed by depositing a conducting material on the carrier layer in a spatially selective manner to form a conductor trace along a predetermined path and at least partially penetrating the carrier layer. In this manner not only the temperature sensor but also it is electric connections can be formed on and fixed to the carrier layer by a printing process which allows the production process to be automated to a high degree.

[0018] According to the present invention there is also provided a heating mat for vehicle component, which heating mat comprises:

a flexible, porous carrier layer, a heating conductor connected to the carrier layer and extending along the carrier layer in a predetermined pattern, a temperature sensor fixed on the carrier layer at a predetermined position and electric connections to the temperature sensor for sensing a signal indicative of the temperature of the temperature sensor, characterized in that the temperature sensor is formed by a temperature sensitive conductor path deposited on the carrier layer such that at least a carrier layer interface region facing the conductor path is embedded by temperature sensitive material of the conductor path.

[0019] Accordingly, the heating mat is provided with a temperature sensor which is fixed to the carrier layer by at least an interface region of the carrier layer being filled by and embedded by material of the conductor path of the temperature sensor, i.e. the structural elements of the porous carrier layer, for example fibres, are embedded by material of the conductor path. In this manner a particularly intimate connection between the conductor paths of the temperature sensor with the carrier layer is present. In other words, at least in an interface region, to the depth into carrier layer which is filled by permeated temperature sensitive material, the conductor path of the temperature sensor and the interface region of the carrier layer for a composite, integrated body. In this manner a tight and intimate, and thus solid connection of the conductor path to the carrier layer is characteristic for the connection of the temperature sensor conductor path to the carrier layer according to the present invention. On the other hand, no additional fasteners or connectors, such as glue or yarn stitches as in the prior art, are present which could influence the thermal connection of the temperature sensor conductor path to the carrier layer.

[0020] In a preferred embodiment the temperature sensitive material of the temperature sensor has a specific electrical resistance which is at least ten times higher than the specific electrical resistance of the heating conductor over an operating temperature range of the heating mat from -40°C to $+150^{\circ}\text{C}$.

[0021] In a preferred embodiment the temperature sensitive material of the temperature sensor is selected from the group consisting of silicon, silicon with carbon filling, conductive polymers, nickel and germanium.

[0022] In a preferred embodiment the carrier layer is made of a textile material, for example a woven fabric or a non-woven fleece, or an open-cell foam material.

[0023] In a preferred embodiment the electric connections of the temperature sensor are formed by conductor traces of conductor material deposited on the carrier layer such that at least carrier layer interface regions are filled with and embedded by conductor material of the conductor traces. In such embodiments the electric connection for sensing the resistance of the conductor path of the temperature sensor are intimately and tightly connected to the carrier layer without presence of any further connecting means or fasteners.

[0024] The invention will now be described with refer-

ence to the accompanying drawings in which:

Fig. 1 shows a schematic plan view of a heating mat according to a first embodiment;

Fig. 2 shows a schematic plan view of a heating mat according to a second embodiment;

Fig. 3 shows a schematic illustration of a cold plasma spraying process for depositing and fixing a conductor path on a carrier layer to form a temperature sensor; and

Fig. 4 shows a schematic illustration of an inkjet printing process for depositing and fixing a conductor path to a carrier layer to form a temperature sensor.

[0025] Fig. 1 shows a plan view of a heating mat 1 from above. The heating mat 1 comprises a flexible, porous carrier layer 2 which may consist of fabric, non-woven fleece or an open-celled foam material.

[0026] On the surface of the carrier layer 2 a heating conductor 4 is placed and fixed to extend along the carrier layer 2 in a predetermined pattern. In this case the heating conductor 4 forms a loop on the carrier layer 2 with superimposed meander patterns. The two end terminals of the heating conductor 4 are connected to a power supply (not shown) which is controlled by a control unit (not shown) to deliver electric power to the heating conductor 4, wherein the level of the electric power is adjusted by the control unit.

[0027] In a predefined position on the carrier layer 2 a temperature sensitive conductor path is provided as temperature sensor 6. Electrical connections 8 are placed on the carrier layer 2 and connected to end portions of the conductor path of the temperature sensor 6. The electric connections 8 are connected to the control unit which in a measuring step applies a measuring voltage over the conductor path of the temperature sensor 6 to sense the voltage drop over the conductor path 6 to thereby determine the resistance of the temperature sensor 6. Based on characteristic curve of the temperature sensor describing the resistance as a function of the temperature, the control unit determines the actual temperature. In this manner the control unit can adjust the electric power supply to the heating conductor in a closed loop control to reach and maintain a set temperature.

[0028] According to the present invention the conductor path of the temperature sensor 6 is printed on the carrier layer by depositing temperature sensitive conductor material on the carrier layer in such a manner that the printed material partially penetrates the porous carrier layer, i.e. permeates into the porous carrier layer material to a certain depth. After solidification of the printed material the conductor path of temperature sensitive material forming the temperature sensor is firmly and intimately connected to the porous carrier layer. In other words, the carrier layer is in an interface region reaching to a

certain depth in the carrier layer embedded by solidified deposited material forming part of the conductor path of the temperature sensor.

[0029] The printing or material deposition process applying the conductor path can be performed with high positioning precision such that the dimensions of the temperature sensor conductor path (length and width and thickness) are precisely controlled, as well as the position relative to the carrier layer 2 and the heating conductor 4. Precise positioning control can in this manner be achieved when using for example printing heads under the control of a digital control unit precisely controlling the operation of the printhead and its relative movement to the carrier layer.

[0030] Fig. 3 is a schematic illustration of a cold plasma spraying process for applying a metal or metal oxide conductor path on a carrier layer, wherein the metal or metal oxide is selected to have a predetermined positive or negative temperature coefficient. Fig. 3 shows a schematic cross-section of a plasma spray gun performing cold plasma spraying. The plasma spray gun comprises an outer anode 20 surrounding a central cathode (not shown to simply the representation). A gas flow 24 (e.g. argon or nitrogen) flows around the central cathode (not shown) and through the anode 20 which is shaped as a constricting nozzle. Plasma is generated by a high voltage discharge which causes localized ionization and a conductive path for a current arc to form between cathode and anode. Current resistance heating in the discharge arc rapidly heats the gas to reach very high temperatures which cause ionization and formation of a plasma. The plasma exits the nozzle as a free or neutral plasma flame (plasma which does not carry electric current). When the plasma is stabilized the electric arc extends down the nozzle, instead of shorting out to the nearest edge of the anode 20. This stretching of the arc is a thermal pinch effect: Cold gas around the surface of a (preferably water cooled) anode 20 is electrically non-conductive and constricts the plasma arc 28, raising its temperature and velocity. Powder of the material to be sprayed is supplied and fed into the plasma flame 28 via a supply port directing a stream of powder to the plasma flame 28. In the plasma arc the injected powder is rapidly heated, melted and accelerated towards the carrier layer 2. The metal particles 26 melted in the plasma flame and accelerated towards the carrier layer are impinging on the surface of the carrier layer where they, still in a flowable state, enter pores of the porous carrier layer to penetrate and permeate into the carrier layer 2 up to a certain depth before they solidify. In the detail of Fig. 3 the melted metal particles are shown as open circles, and the solidified deposited metal layer is shown as a hatched layer.

[0031] In cold plasma spraying very low particle sizes of preferably lower than 20 μm are used. The small melted particles when leaving the plasma arc with high velocity already start to cool on the way to the carrier layer and eventually solidify inside of the carrier layer which is penetrated by the deposited material up to a certain

depth.

[0032] Deposition of the conductor material is continued until a layer of a predetermined thickness has been deposited. In this manner it is possible deposit very thin layers of a thickness of only 10 μm , but also thicker layers of for example up to 2 mm. As has been explained at least a lower portion of the coated conductor path extends into the porous carrier layer material and embeds this interface region of the carrier layer material after solidification. An upper portion of the coated conductor path may project from the surrounding surface of the carrier layer 2.

[0033] By controlling relative movement of the plasma spray gun over the carrier layer the lateral dimensions (length and width) of the conductor path formed may be precisely controlled. Positioning of the plasma spray gun relative to the carrier layer 2 may be controlled in a precise and automated manner by a control unit which in addition may also control the operation of the plasma spray gun which allows to apply and fix temperature sensor conductor paths with precisely controlled dimensions (length, width and thickness) and accurately positioned on the carrier layer. Furthermore, the deposition with at least partial penetration of the deposited material into the carrier layer ensures a tight and intimate connection of the applied conductor path 6 to the carrier layer 2. This is schematically shown in the lower detail of Fig. 3 where the already solidified material layer 6 is shown as partly extending into the carrier layer structure and embedding the carrier layer structure elements. The carrier layer 2 is shown there in a very schematic manner to consist of cells of an open-cell foam. Further droplets 28 are sprayed onto the already solidified layer 6 until the desired layer thickness is reached.

[0034] Fig. 4 shows an alternative way of depositing a conductor path as a temperature sensor 6, in this case by an inkjet printhead which is shown in a schematic cross-section (no details of the inkjet printing mechanism are shown). Conductive ink 32 is ejected by a nozzle which expels ink droplets 6 which are directed towards the carrier layer 2. The conductive ink may be a slurry of fine metal or metal oxide powder dispersed in a liquid binder. After impinging on the carrier layer surface the ink droplets permeate into the carrier layer material up to a certain depth. The liquid binder may have a low boiling point so that it evaporates after the printing process which leads to solidification of the applied conductor path. Alternatively, the binder can be polymerizable, and the deposition process can be performed such that the binder polymerizes after the printing process to thereby create a solidified conductor path 6. In the detail of Fig. 4 the ink droplets are shown as black circles and the solidified deposited layer is shown as a hatched layer.

[0035] Also in this case the applied printed material is permeating into the porous carrier layer 2 which therefore in an interface region of the printed material is embedded by the solidified material of the printed conductor path 6 as is schematically shown in the detailed view in the lower

part of Fig. 4. Also in this case the inkjet printing head can be precisely controlled by a control unit to form, in an automated manner, a conductor path of precisely defined dimensions (width lengths and thickness) and at a precisely controlled position on the carrier layer. Typical thicknesses of the printed conductor path may be in the range of 10 μm to 2 mm. Length and width are typically chosen such that the area covered by the conductor path is in the range from 1 mm² to 20 mm².

[0036] Fig. 2 shows a second embodiment of a heating mat 1. The second embodiment differs from the first embodiment shown in Fig. 1 by the position of the temperature sensor 6 and its electric connection. In the embodiment of Fig. 2 the temperature sensor 6 is provided with one electric connection 8 only. The function of the second electric connection of the temperature sensor 6 is taken over by one end portion of the heating conductor 4, i.e. the temperature sensor 6 is in electric connection with one end portion of the heating conductor 4. This may for example be the end portion of the heating conductor 4 which is connected to ground. In other words, in this configuration the ground connection is shared by the heating conductor and the temperature sensor.

Claims

1. Method for producing a heating mat for a vehicle component, comprising the steps of:
 - providing a flexible, porous carrier layer (2),
 - connecting a heating conductor (4) to the carrier layer (2) to extend along the carrier layer in a predetermined pattern, and
 - fixing a temperature sensor (6) on the carrier layer (2) at a predetermined position and providing electric connections (8) to the temperature sensor for sensing a signal indicative of the temperature of the temperature sensor, **characterized in that** the temperature sensor (6) is fixed on the carrier layer by depositing temperature sensitive material having a temperature dependent resistivity on the carrier layer (2) in a spatially selective manner to form a conductor path of predefined dimensions and at least partially penetrating the carrier layer (2).
2. Method according to claim 1, **characterized in** the said depositing of temperature sensitive material with at least partial penetration of the carrier layer is performed by depositing temperature sensitive material that is, at least at the time of deposition, in a flowable state.
3. Method according to claim 1 or 2, **characterized in** the said depositing of temperature sensitive material is performed by plasma spraying the material onto the carrier layer (2).
4. Method according to claim 3, **characterized in** the said depositing of temperature sensitive material is performed by cold plasma spraying.
5. Method according to claim 1 or 2, **characterized in** the said depositing of temperature sensitive material is performed by inkjet printing or screen printing the temperature sensitive material onto the carrier layer (2) and letting the of temperature sensitive material solidify after printing.
6. Method according to any of the preceding claims, **characterized in** the electric connections (8) of the temperature sensor (6) are formed by depositing a conducting material on the carrier layer (2) in a spatially selective manner to form a conductor trace along a predetermined path and at least partially penetrating the carrier layer.
7. Heating mat (1) for a vehicle component comprising:
 - a flexible, porous carrier layer (2),
 - a heating conductor (4) connected to the carrier layer (2) and extending along the carrier layer in a predetermined pattern,
 - a temperature sensor (6) fixed on the carrier layer at a predetermined position and
 - electric connections (8) to the temperature sensor (6) for sensing a signal indicative of the temperature of the temperature sensor, **characterized in that** the temperature sensor (6) is formed by a temperature sensitive conductor path deposited on the carrier layer such that at least a carrier layer interface region facing the conductor path is embedded by temperature sensitive material of the conductor path.
8. Heating mat (1) according to claim 7, **characterized in that** the temperature sensitive material of the temperature sensor (6) has a specific electrical resistance that is at least 10 times higher than the specific electrical resistance of the heating conductor (4) over an operating temperature range of the heating mat from -40°C to +150°C.
9. Heating mat (1) according to claim 7 or 8, **characterized in that** the temperature sensitive material is selected from the group consisting of silicone, silicone with carbon filling, conductive polymers, nickel and germanium.
10. Heating mat (1) according to any of claims 7 to 9, **characterized in that** the carrier layer (2) is made of a textile material or an open-cell foam material.
11. Heating mat according to any of claims 7 to 10, **characterized in that** the electric connections of the temperature sensor are formed by conductor traces of

conductor material deposited on the carrier layer such that at least carrier layer interface regions facing the conductor traces are embedded by conductor material of the conductor traces.

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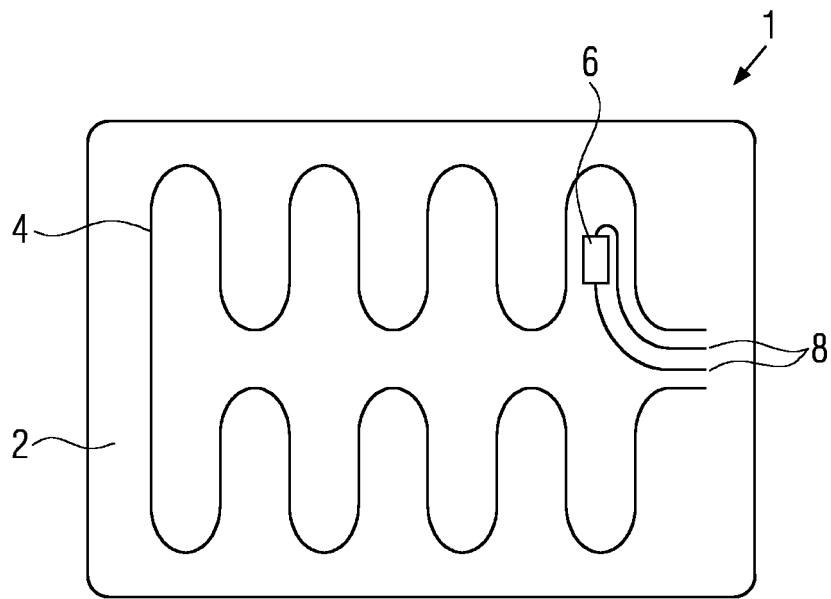


FIG. 1

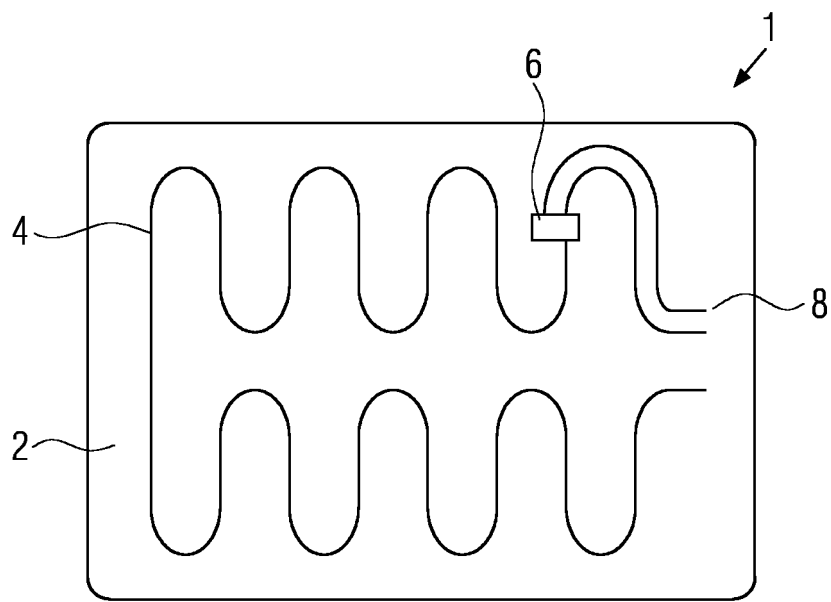


FIG. 2

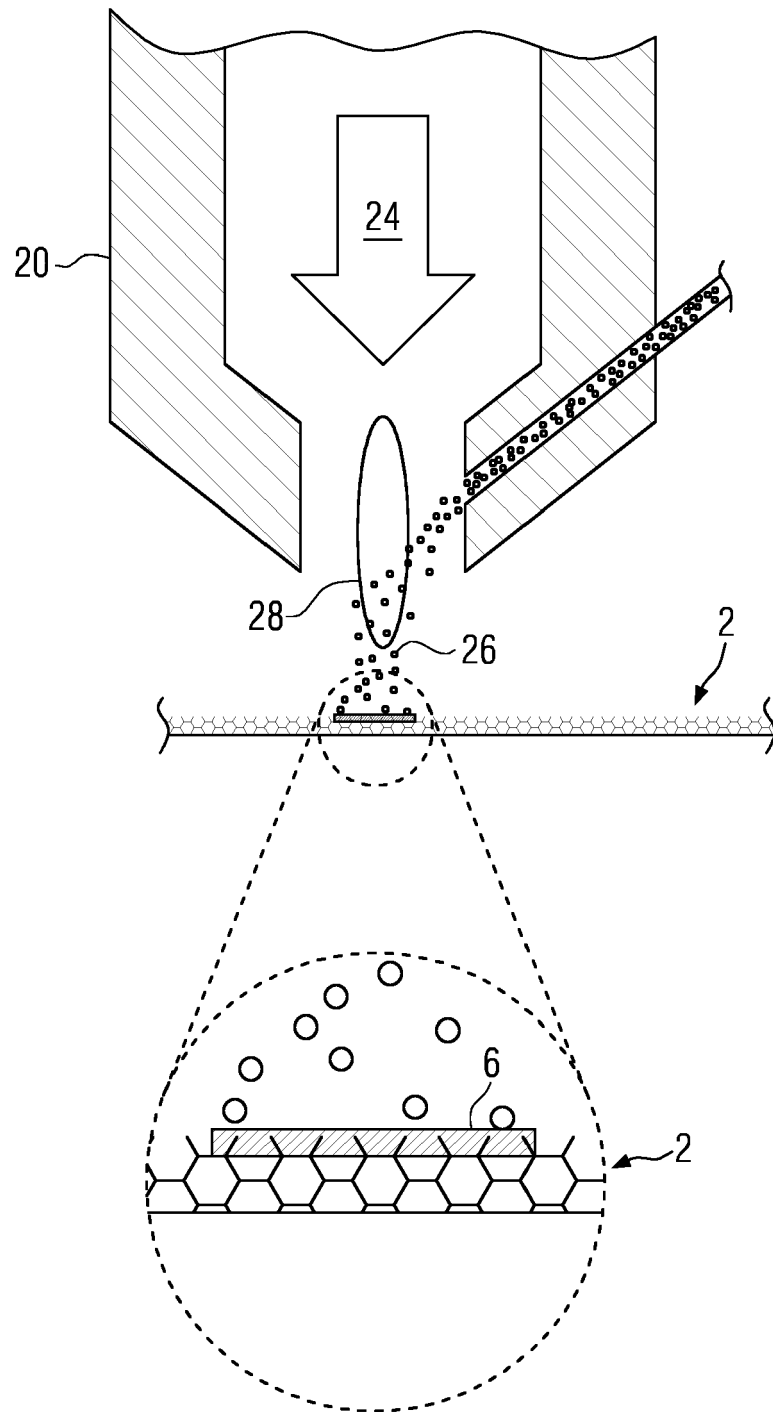


FIG. 3

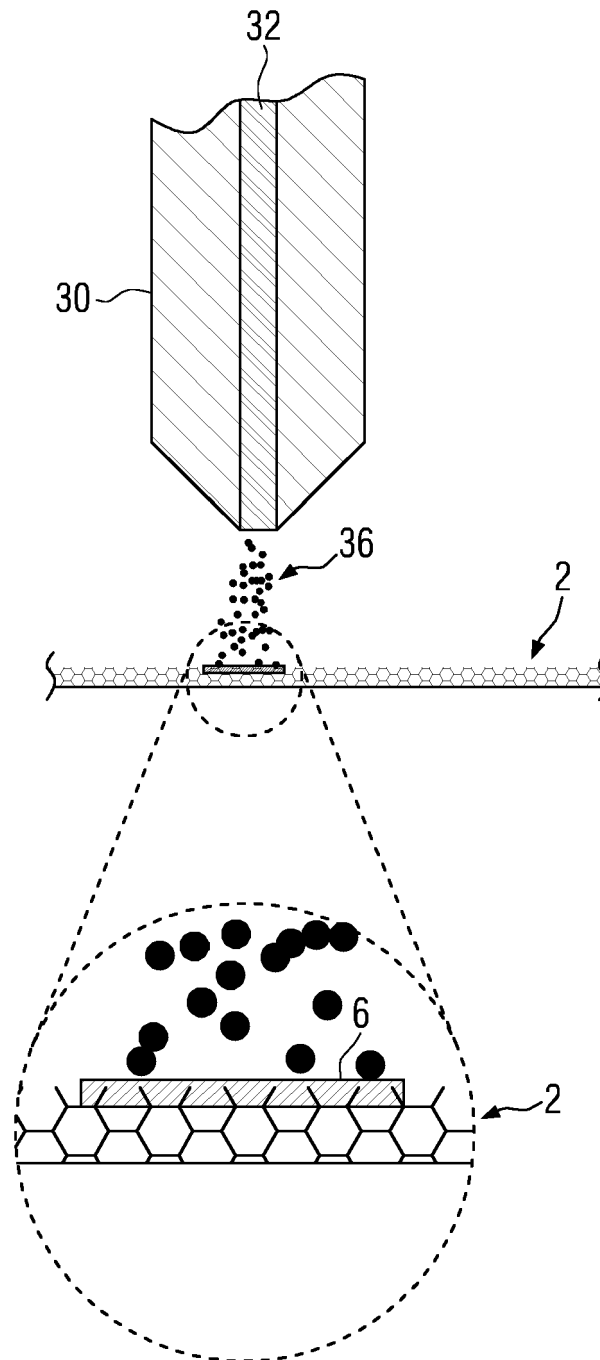


FIG. 4



EUROPEAN SEARCH REPORT

 Application Number
 EP 18 20 8358

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 18 20 8358

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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