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(54) MULTILAYER ULTRATHIN AND FLEXIBLE UNIT HEATER CELLS FOR INFRARED STEALTH

(57) The present invention relates to an ultrathin, multilayer and encapsulated surface element (1) for providing thermal signature adaptation with the purpose of infrared stealthing, and being also suited for camouflage in the visible, the element comprising :
- a lower layer made of an insulation substrate (3, 30) ;
- an intermediate layer comprising a plurality of conductive tracks (4) connectable to a power supply ;
- a plurality of active heat dissipation elements (2, 20) connected to the conductive tracks (4) in the intermediate layer and capable to provide a temperature increase in a given time interval when a current is fed into said heat dissipation elements ;
- an upper layer made of a protective layer (5) ;
characterized in that the heat dissipation elements (2, 20) and the conductive tracks (4) are printed on the insulation substrate (3, 30) and in that the heat dissipation elements (2) have a size and are organized according to a spatial arrangement so as to provide a predetermined infrared spatial resolution, when a current is fed into said dissipation elements.

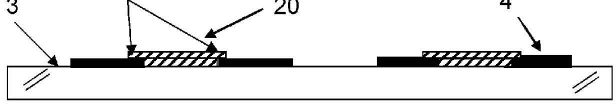

FIG. 4A

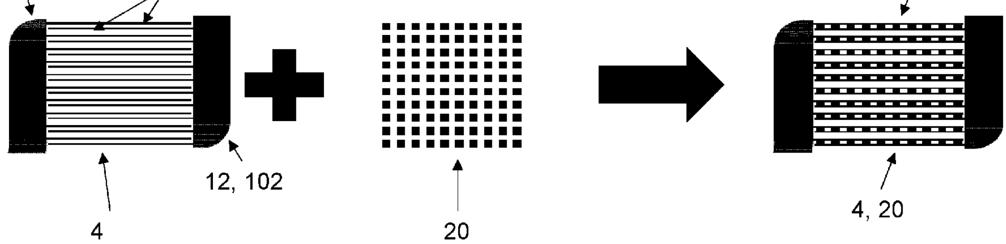

FIG. 4B

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Description

Field of the Invention

[0001] The present invention relates to a multilayer, ultra-thin and flexible system of unit heater cells, obtained by printed electronic technology, for infrared (IR) stealth.

[0002] The invention could also be used in applications in fields like aeronautics or automotive industry, for providing customized heating parts regarding localized areas, such as for example in defrost applications.

Background and Prior Art

[0003] In the context of current military conflicts, and mainly asymmetric conflicts, the protection of troops and equipment is essential. Military strategies in mission theatres are also permanently in evolution, mainly due to the emergence of increasingly efficient and sophisticated technologies. This essential aspect of protection for the troops is now reinforced by calls for proposals of the European Defence Industrial Development Programme (EDIDP).

[0004] On the ground, the main objective in terms of protection and therefore stealth is, according to danger order:

- not to be seen at long distance (12-20 km) ;
- not to be recognized, with change of signature occurring at medium distance (4-12 km) ;
- not to be identified, with possible use of decoy system (<4 km).

[0005] Day or night, a widely used means of detection remains infrared thermography, which enables to perceive the thermal signature of a soldier, (armoured) vehicle, etc.

[0006] The idea at the basis of the present invention is therefore to be able to couple both camouflage in the visible while being stealthy in the infrared, either by blending into the environment (i.e. becoming "invisible") or by adjusting the thermal signature to dupe the enemy.

[0007] Document US 8,077,071 B2 discloses a number of systems and assemblies for simultaneous adaptive camouflage, concealment and deception. The assemblies that can be used in the systems include a vinyl substrate layer and a miniaturized thermoelectric device array secured to the vinyl substrate layer. The miniaturized thermoelectric device array is configured to provide an adaptive thermal signature to a side of the miniaturized thermoelectric device array that faces outward from the vinyl substrate layer. A flexible image display matrix can be secured on the vinyl substrate layer, said flexible image display matrix being configured to display visual images. A laminate layer can be secured over the vinyl substrate layer covering the flexible image display matrix and the miniaturized thermoelectric device array to provide protection and strengthen the assemblies. One or more nanomaterials can be disposed on the vinyl substrate layer or the laminate layer to provide thermal or radar suppression. This disclosure seems to be only a concept, a suggestion for combining a succession of new technologies not yet turned into practice, which would be expensive and lacking flexibility.

[0008] Document WO 2009/040823 A2 relates to a thermal vision countermeasure system to enable concealment of objects from identification by thermal imaging night vision systems, including a screen made of thermoelectric (Peltier effect) modules, disposed between the target object and an IR detector. The screen, formed of a number of thermoelectric units, is coupled to the target object, and the thermoelectric unit includes a thermoelectric cooler (TEC) module coupled to a plate formed of a material selected from aluminium, copper, or aluminium with copper, the plate being substantially larger than the TEC module. This technology allows full coverage with interchangeable and bee structure modules, providing IR cartography and radar stealth. However this solution is complex, expensive to develop, provides poor cartography resolution and does not allow visible dissimulation.

[0009] Document WO 2012/169958 A1 discloses a device for signature adaptation, comprising at least one surface element arranged to assume a determined thermal distribution, wherein said surface element comprises at least one temperature generating element arranged to generate a predetermined temperature gradient to a portion of said surface element. The surface element also comprises at least one radar suppressing element, wherein said radar suppressing element is arranged to suppress reflections of incident radio waves. The invention also concerns an object provided with a device for signature adaptation. A full coverage is obtained thanks to interchangeable and honeycomb-like hexagonal unitary panels structure, with good spatial resolution. However, this solution is complex, expensive to develop, not easy to attach on site and does not provide visible dissimulation (not embedded).

[0010] Document US 9,777,998 B1 discloses a device provided for camouflaging an object from an infrared detection apparatus. The device includes a cloak positionable between the object and the infrared detection apparatus. The cloak includes a layer of infrared absorptive material including a plurality of silicon nanowires. A flexible substrate has a first surface operatively connected to an inner surface of the layer. The substrate includes a heat dissipation arrangement for dissipating heat generated by the cloak during operation. An array of infrared emitters is operatively connected to a second surface of the substrate. The array of infrared emitters selectively radiates an infrared pattern to disguise the object to the infrared detection apparatus. The heat dissipation arrangement includes a channel formed in the flexible substrate and adapted for receiving a cooling fluid therein. The heat dissipation arrangement further includes a pump for recirculating the cooling fluid through the channel. Each IR emitter is electrically connected to a corresponding contact by a corresponding line, each contact is operatively connected to a processing unit, e.g. a controller. The controller is configured to selectively actuate each IR emitter such that each actuated IR emitter transmits an infrared signal that is visible to IR reader. This disclosure is very conceptual and poor in details.

[0011] Document FR 2 733 311 A1 discloses a fibre optics network having a grid of fibre optic cables with a section having the sleeve removed and fed from an input point. Different infrared bands are generated and radiated from one of the optical lines. The system measures the background radiance in the different infrared bands and sets the radiated levels to provide camouflage. The optical cables are embedded in a flexible outer section.

[0012] Document CN 110058428 A relates to a carbon material based double-sided active infrared emissivity adjustment thin film, in particular to a thin film material based on a carbon material (including graphene, carbon nanotubes, amorphous carbon, carbon black and the like) and ionic liquid. A flexible device with double-sided infrared radiation control can be realized through a voltage regulation mode, with low working voltage and power consumption, large emissivity adjusting amplitude and simple structure. The adjustment thin film is suitable for large-scale production, has good mechanical bending performance, can be widely applied to infrared camouflage or stealth on the surfaces of automobiles, ships, airplanes, satellites and the like, and can also be applied to the surfaces of batteries, micro-nano satellites and the like to realize temperature control.

[0013] Lin Xiao et al., in Fast Adaptive Thermal Camouflage Based on Flexible VO2/Graphene/CNT Thin Films, Nano Lett. 2015, 15, 8365-8370 (Am. Chem. Soc.), demonstrate an active cloaking device capable of efficient thermal radiance control, which consists of a vanadium dioxide (VO_2) layer, with a negative differential thermal emissivity, coated on a graphene/carbon nanotube (CNT) thin film. A slight joule heating drastically changes the emissivity of the device, achieving rapid switchable thermal camouflage with a low power consumption and excellent reliability. This device is intended to find wide applications not only in artificial systems for infrared camouflage or cloaking but also in energy-saving smart windows and thermo-optical modulators.

[0014] Prior art IR stealth solutions generally present the following drawbacks:

- they are expensive ;
- they have a lack of flexibility in respect of on-site fixing or repair;
- they do not satisfy existing visible and aesthetic constraints ;
- they usually have a heavy and/or cumbersome design.

Aims of the Invention

[0015] The present invention aims to provide an efficient active IR stealth system, which is inexpensive, light and not bulky as well.

[0016] Another goal of the invention is to provide a flexible, easy-to-attach, embedded, customizable in terms of shape and/or pattern and object-matching solution.

[0017] Furthermore, the invention is intended to provide a spatial IR mapping with suitable resolution.

Summary of the Invention

[0018] A first aspect of the present invention relates to an ultrathin, multilayer and encapsulated surface element for providing thermal signature adaptation with the purpose of infrared stealthing, and being also suited for camouflage in the visible, the element comprising :

- a lower layer made of an insulation substrate ;
- an intermediate layer comprising a plurality of conductive tracks connectable to a power supply ;
- a plurality of active heat dissipation elements connected to the conductive tracks in the intermediate layer and capable to provide a temperature increase in a given time interval when a current is fed into said heat dissipation elements ;
- an upper layer made of a protective layer;

characterized in that the heat dissipation elements and the conductive tracks are printed on the insulation substrate and in that the heat dissipation elements have a size and are organized according to a spatial arrangement so as to provide a predetermined infrared spatial resolution, when a current is fed into said dissipation elements.

[0019] According to preferred embodiments, the surface element additionally comprises one or a suitable combination of the following features :

- the spatial arrangement is a two-dimensional array of cells or pixels comprising heat dissipation elements regularly spaced in two orthogonal directions, each cell or pixel being independently connectable to the power supply via the conductive tracks ;
- the spatial arrangement is a two-dimensional array of cells or pixels comprising heat dissipation elements regularly spaced in two orthogonal directions, each cell or pixel being connectable in a multiplexed manner to the power supply via the conductive tracks ;
- the heat dissipation elements are made of carbon containing material, PTC ferroelectric material or any

resistive material having a resistance higher than the resistance of the conductive tracks ;

- the carbon-containing heat dissipation elements are made of carbon black, amorphous carbon, graphite, graphene nanoplatelets or carbon nanotubes ;

- the resistive material having a resistance higher than the conductive tracks is made of tungsten, a metallic alloy such as nichrome (NiCr), a transparent conducting oxide (TCO) film material such as aluminium-doped zinc oxide (AZO) or indium tin oxide (ITO), or a transparent conducting polymer such as Poly(3,4-ethylenedioxythiophene) PEDOT: poly(styrene sulfonate) PSS ;

- the conductive tracks are made of silver, gold, copper, aluminium or zinc ;

- the heat dissipation elements and the conductive tracks attachment to the substrate is obtained by inkjet, screen printing or serigraphy, flexography or sintering or other printing electronic deposition methods, possibly combined with heating or radiation such as oven, IPL, IR, UV, laser, and in particular 3D printing electronic deposition methods, such as spray with stencil, micro spray, 3D inkjet or ink dispensing ;

- the insulation substrate is made of a glass plate or of a polyimide film ;

- each cell comprises a module of conductive tracks having an input electrode and an output electrode, said input electrode and said output electrode having the form of interdigitated combs, and comprising an array of heat dissipation elements having the form of studs connected between the respective teeth of the interdigitated combs ;

- each cell or pixel is obtained by firstly printing the module of conductive tracks on the insulation substrate and secondly printing the array of heat dissipation elements onto both insulation substrate and module of conductive tracks, so that the heat dissipation elements are brought into close electrical contact with the module of conductive tracks ;

- each heat dissipation element has an essentially squared shape with an upper surface and a lower surface, said lower surface being provided with a side recess on two parallel edges, so that the heat dissipation element can be inserted between adjacent teeth of the first electrode and the second electrode respectively ;

- each cell or pixel has an independent input connection, respectively an independent output connection with the power supply ;

- each cell or pixel has a multiplexed connection with the power supply, it means that each cell or pixel of the two-dimensional array is powered by selecting respective row and column powering tracks corresponding to the (X, Y) position of the cell in the two-dimensional array ;

- row and column powering tracks overlap with insulation in the array thanks to positioning dielectric elements preventing unwanted electric contacts at the crossover points of the row and column powering tracks ;

- a flat or surface-mounted (SMD) diode is mounted on each pixel output, so that no leakage current could pass to an adjacent pixel and improperly lighten in whole or in part the corresponding row and column ;

- the protective layer is an encapsulating insulating layer obtained by serigraphy or spray and made of dielectric material such as an oxide, a polymer or a ceramic material.

[0020] A second aspect of the present invention relates to the use of one or more surface elements as described above, for providing an object or a person with a cover, sheet, blanket, casing or roofing capable of adapting the thermal signature of said object or person with the purpose of infrared stealthing, deception, camouflage, decoying or concealment.

[0021] Preferably, the plurality of heat dissipation elements selectively radiate a surface infrared pattern allowing to avoid the person or the object covered by said one or more surface elements to be detected by an infrared detection device.

Brief Description of the Drawings

[0022]

FIG. 1 schematically represents the principle of an active system of heating resistors printed on a thermally and electrically resistive substrate, according to the present invention.

FIG. 2A and FIG. 2B schematically represent architectures for an active system according to the present invention, under the form of 3X3 independent heater modules, respectively of 10x10 multiplexed modules.

FIG. 3A and FIG. 3B schematically represent embodiments according to FIG. 1, wherein the thermally and electrically resistive substrate is a metal substrate covered with a dielectric layer, respectively a glass substrate.

FIG. 4A schematically represents an embodiment according to FIG. 1, wherein the active material is a ferroelectric positive temperature coefficient (PTC) material. FIG. 4B schematically represents a module comprising the active material of FIG. 4A, wherein the module is obtained by the superposition of a conductive layout and a T-dependent resistive layout.

FIG. 5A schematically represents an embodiment according to FIG. 4A, wherein the substrate is made of glass. FIG. 5B is a picture of a demonstrator according to FIG. 5A, with 3x3 independent heater modules.

FIG. 6A schematically represent an embodiment especially designed to be used in the case of multiplexed modules and wherein the substrate is made of a polyimide layer (Kapton®). FIG. 6B represents a detail view showing the dielectric elements provided for track separation in the embodiment of FIG. 6A.

FIG. 7 shows a video excerpt of a IR pattern radiated using a 3x3 independent cells demonstrator according to an embodiment of the invention, said pattern being visualized with a computer equipped with a IR camera.

FIG. 8 shows a multiplexed cells demonstrator in which the activation of a pixel induces leakage current and residual lightning in the row and the column corresponding to this pixel.

FIG. 9 is a picture of a demonstrator corresponding to the configuration of FIG. 8, in which a SMD diode has been inserted at the output of each pixel in order to solve the above-mentioned leakage issue.

FIG. 10 shows an example of IR pattern radiated using a multiplexed cells demonstrator according to an embodiment of the invention, said pattern being visualized with a tablet computer equipped with a thermal camera (FLIR Systems, Inc.).

Detailed Description of the Invention

[0023] The present invention is based on an active (i.e. controllable) system 1 of heating resistors 2 printed on a thermally and electrically resistive substrate 3, as shown in FIG. 1. For example the resistive heating layer 2 printed on the resistive substrate 3 can be made of metal itself (e.g. silver conductive paste) or of a carbon-based material with power feeds under the form of a conductive layer 4 made of silver (or copper, aluminium, etc.). The underlying principle is that the heating element 2 is based on different resistivity between carbon and silver. Useful printing techniques are for example serigraphy (also called screen printing or silkscreen), inkjet, flexography, sintering and other printing electronic deposition methods, possibly combined with heating or radiation (oven, IPL, IR, UV, laser, etc.). In addition, other new 3D printing electronic deposition methods can also be used, such as spray (with stencil), micro spray, 3D inkjet , ink dispensing, etc. In this case, direct printing can be performed on 3D objects.

[0024] The whole multilayer system is finally encapsulated by an insulating protective layer 5 obtained for example by serigraphy or spraying and made of off-the-shelf dielectric components such as oxides (e.g. Al_2O_3, ZnO, TiO_2, etc.), polymers (polycarbonate, polyimide, PE, PP, PET, PVC, etc.) or ceramic-based materials.

[0025] The IR stealth technology according to the invention is intended to provide two functions :

- firstly, using active material in which temperature variation is a function of a controlled applied voltage and current;
- secondly, achieving an IR mapping having a given resolution by using a matrix of IR printed unit modules globally radiating IR pattern.

[0026] The following examples provide matrix/2D architectures that illustrate the general idea of the present invention. A first example (FIG. 2A) shows 3x3 independent modules 10 (from the point of view of power feeding) and a second example (FIG. 2B) shows 10x10 multiplexed modules 100. The independent modules 10 have each an independent power feed while in the multiplexed module 100, a specific module is chosen by power feeding a specific line and a specific column (matrix power feed).

[0027] Further, considering a multiplexed configuration of functionally independent modules/cells, one module 10 equals one pixel (FIG. 2A). The resistive elements 2 (e.g. made of carbon containing material) are under the form of a regularly spaced studs layout embedded in conductive tracks 4 (e.g. made of silver) under the form of combs (see detailed description below). In this array configuration, each cell or pixel 10 can be activated independently.

[0028] In another example of multiplexed modules configuration (FIG. 2B), each module may comprise 4 pixels. A power supply distributes the current to the pixels either sequentially or by selecting/programming a specific pixel to heat in a matrix way (selection of a row and a column). Each cell or pixel has a multiplexed connection with the power supply, it means that each cell or pixel of the two-dimensional array is connected to a "column" input electrode and to a "row" output electrode (or vice versa) so that a determined pixel in position (X, Y) is powered by selecting respective row and column powering tracks in the two-dimensional array. Row and column powering tracks suitably overlap in the array thanks to positioning dielectric elements 7 preventing electric contacts at the crossover points of the row and column powering tracks (see below).

Description of Preferred Embodiments of the Invention

[0029] In a first embodiment (FIG. 3A), the inventors used a metallic support 3 as a substrate covered with an insulating layer (dielectric) 6. The dielectric layer 6 was a PVC material layer having a thickness up to 200μm. Conductive tracks 4 were obtained by screen printing of silver-based microparticles. The layout (architecture) was made of linear simple tracks. Simulations showed an important heat dissipation through the underlying metal substrate and a non-uniform increase of temperature in a hexagonal full silver motif/heater module was observed (not shown).

[0030] In a second embodiment (FIG. 3B), the metallic substrate covered with a dielectric insulating layer was replaced with a glass substrate 3, which is a good thermal and electric insulator. The conductive tracks 4 and architecture layout were unchanged.

[0031] The use of a substrate material having a drastically reduced thermal conductivity led to a much better spatial IR resolution (but with some local increase of temperature). Silver based heater tracks gave high ΔT but also gave uniform T mapping and further good IR spatial resolution. Different motifs/heater modules were investigated (hexagonal Ag/C, spiral Ag, ...) with the occurrence of non-uniform temperature and current distribution (not shown). This showed the need of further increasing IR spatial resolution.

[0032] In a third embodiment, while still utilizing a glass substrate 3 as a thermal insulator, an active material 20, under the form of a ferroelectric positive temperature coefficient (PTC) material, was used as carbon resistive material, in combination with conductive silver tracks 4, as described above (FIG. 4A). Each cell belongs to an array making a heat dissipation element and is obtained by the superposition of a silver layout 4 on a carbon layout 20 (FIG. 4B), which will be described with more details here below.

[0033] Each cell 10, 100 comprises a module of conductive tracks 4 having an input electrode 11, 101 and an output electrode 12, 102, having the form of two interdigitated combs, and comprising an array of heat dissipation elements 20 connected between the respective teethes 13, 103 of the interdigitated combs. Note that respective 10, 11, 12, etc. and 100, 101, 102, etc. reference signs refer to the embodiments with 3X3 independent heater modules and 10x10 multiplexed heater modules. The "cell" element can also be referred to as a "pixel" with reference to the IR spatial resolution of the device.

[0034] Preferably, each cell or pixel 10, 100 is obtained by firstly printing, for example by screen printing, the module of conductive tracks 4 on the insulating substrate 3, 30 and secondly printing the array of heat dissipation elements 20 onto both insulation substrate 3, 30 and module of conductive tracks 4, so that the heat dissipation elements are brought into close electrical contact with the module of conductive tracks 4. Each heat dissipation element has preferably a squared shape with an upper surface and a lower surface, said lower surface being provided with a side recess 21 on two edges, so that the heat dissipation element can be inserted between adjacent teethes 13, 103 of the first electrode 11, 101 and the second electrode 12, 102 respectively (see FIG. 4A).

EXAMPLE 1

[0035] The non-multiplexed heater motif size is: 4x4 cm^2 (see FIG. 5A and FIG. 5B). The material is composed of silver tracks having outside input/output electrode width of 10mm and interdigitated width of 0.4mm. The PTC carbon resistor is made of 100 small square units (2x2mm^2). A temperature of about 50°C was obtained after 30s with a current of 210mA. A high spatial resolution is obtained with self-regulation, low current, homogeneity. The drawbacks are wide current feeds and a non-flexible substrate (glass).

[0036] In a fourth embodiment, Kapton® (polyimide film, DuPont™) has been used as a thermal insulator and flexible substrate 30 (FIG. 5A). The active material is again PTC (ferroelectrics) material 20 combined with conductive silver tracks 4.

[0037] The coupling of track width reduction with a PTC effect allows to perfectly localize the increase of temperature and thus provides high spatial resolution, with good time response (ΔT/Δt high, low current) and self-regulation (1~40mA, V~24V). The tracks were initially chosen very large (10 mm) outside the patch but their width could be reduced/optimized later on up to 10 times (not shown). As an additional advantage, the device is flexible.

EXAMPLE 2

[0038] In an example demonstrator with 3x3 independent cells (not shown), a heater motif of 4$\times$4cm^2 is provided with 9 stealth cells with Ag tracks of 10mm width, Ag interdigitated tracks of 0.4 mm width and 100 units PTC-C resistors pixels of 2$\times$2mm^2. The substrate is Kapton®.

[0039] The (T, I, V) characteristics are the following :

- ΔT ~50°C after 30s ;
- 1=210mA.

[0040] An example of obtainable IR pattern is shown on FIG. 7.

[0041] In an alternative embodiment (FIG. 6A), the architecture is a 10x10 multiplexed configuration. The multiplexed solution has a number of advantages : save space, reduce the number of connectors needed to power the device (for 10x10 multiplexed, 20 connectors instead of 200 connectors for 10x10 independent cells and no space available in the center), easier control of IR cartography. Further, in this embodiment, a dielectric layer 7 (e.g. Al_2O_3) is provided for electrode separation (FIG. 6B).

EXAMPLE 3

[0042] In an example demonstrator with 10x10 multiplexed cells (not shown), the stealth cells are provided with Ag tracks of 1mm width, Ag interdigitated of 0.4 mm width and 9 units PTC-C resistors pixels of $2\times2mm^2$. The substrate is Kapton®. The heater motif unit is $1.2\times1.2cm^2$.

[0043] The (T, I, V) characteristics are the following :

- ΔT 20-30°C after 30s ;
- 1=100mA@60V.

[0044] In this last configuration, leakage current was observed, leading to some residual lightning 9 of the row and the column corresponding to the selected unit cell 8 (see FIG. 8). The problem was solved by inserting a flat or surface-mounted (SMD) diode 80 on each pixel output, so that the current could not pass to an adjacent pixel (FIG. 9). The insertion is performed, as known in the art, by a "pick & place" method using a conductive glue in order to ensure proper electric connection. Advantageously the SMD diode characteristics are 100V/1A (100 diodes for a 10 by 10 multiplexed device).

List of reference symbols

[0045]

1	system of unit heater cells
2	resistive heating layer
3	insulating substrate
4	conductive layer
5	protective layer (encapsulation)
6	dielectric layer
7	dielectric layer element for electrode separation
8	selected pixel
9	pixels with leakage current
10	independent module
11	input electrode
12	output electrode
13	electrode tooth
20	layer of PTC ferroelectrics material
21	recess
30	layer of polyimide substrate (Kapton®)
80	SMD diode
100	multiplexed modules
101	input electrode
102	output electrode
103	electrode tooth

Claims

1. An ultrathin, multilayer and encapsulated surface element (1) for providing thermal signature adaptation with the purpose of infrared stealthing, and being also suited for camouflage in the visible, the element comprising :

   - a lower layer made of an insulation substrate (3, 30) ;
   - an intermediate layer comprising a plurality of conductive tracks (4) connectable to a power supply ;
   - a plurality of active heat dissipation elements (2, 20) connected to the conductive tracks (4) in the intermediate layer and capable to provide a temperature increase in a given time interval when a current is fed into said heat dissipation elements ;
   - an upper layer made of a protective layer (5) ;

   characterized in that the heat dissipation elements (2, 20) and the conductive tracks (4) are printed on the insulation substrate (3, 30) and **in that** the heat dissipation elements (2) have a size and are organized according to a spatial arrangement so as to provide a predetermined infrared spatial resolution, when a current is fed into said dissipation elements.

2. The surface element according to Claim 1, wherein the spatial arrangement is a two-dimensional array of cells or pixels (10) comprising heat dissipation elements (2, 20) regularly spaced in two orthogonal directions, each cell or pixel (10) being independently connectable to the power supply via the conductive tracks (4).

3. The surface element according to Claim 1, wherein the spatial arrangement is a two-dimensional array of cells or pixels (100) comprising heat dissipation elements (2, 20) regularly spaced in two orthogonal directions, each cell or pixel (100) being connectable in a multiplexed manner to the power supply via the conductive tracks (4).

4. The surface element according to Claim 1, wherein the heat dissipation elements (2, 20) are made of carbon containing material, PTC ferroelectric material or any resistive material having a resistance higher than the resistance of the conductive tracks (4).

5. The surface element according to claim 4, wherein the carbon-containing heat dissipation elements (2, 20) are made of carbon black, amorphous carbon, graphite, graphene nanoplatelets or carbon nanotubes.

6. The surface element according to claim 4, wherein the resistive material having a resistance higher than the conductive tracks (4) is made of tungsten, a metallic alloy such as nichrome (NiCr), a transparent conducting oxide (TCO) film material such as aluminium-doped zinc oxide (AZO) or indium tin oxide (ITO), or a transparent conducting polymer such as

Poly(3,4-ethylenedioxythiophene) PEDOT: poly(styrene sulfonate) PSS.

7. The surface element according to claim 1, wherein the conductive tracks (4) are made of silver, gold, copper, aluminium or zinc.

8. The surface element according to claim 1, wherein the heat dissipation elements (2, 20) and the conductive tracks (4) attachment to the substrate (3, 30) is obtained by inkjet, screen printing or serigraphy, flexography, sintering or other printing electronic deposition methods, possibly combined with heating or radiation such as oven, IPL, IR, UV, laser, and in particular 3D printing electronic deposition methods, such as spray with stencil, micro spray, 3D inkjet or ink dispensing.

9. The surface element according to claim 1, wherein the insulation substrate (3, 30) is made of a glass plate or of a polyimide film.

10. The surface element according to claim 2 or 3, wherein each cell (10, 100) comprises a module of conductive tracks (4) having an input electrode (11, 101) and an output electrode (12, 102), said input electrode (11, 101) and said output electrode (12, 102) having the form of interdigitated combs, and comprising an array of heat dissipation elements (2, 20) having the form of studs connected between the respective teeth of the interdigitated combs.

11. The surface element according to claim 10, wherein each cell or pixel (10, 100) is obtained by firstly printing the module of conductive tracks (4) on the insulation substrate (3, 30) and secondly printing the array of heat dissipation elements (2, 20) onto both insulation substrate (3, 30) and module of conductive tracks (4), so that the heat dissipation elements are brought into close electrical contact with the module of conductive tracks (4).

12. The surface element according to claim 11, wherein each heat dissipation element has an essentially squared shape with an upper surface and a lower surface, said lower surface being provided with a side recess (21) on two parallel edges, so that the heat dissipation element can be inserted between adjacent teeth of the first electrode and the second electrode respectively.

13. The surface element according to claim 2, wherein each cell or pixel (10) has an independent input connection, respectively an independent output connection with the power supply.

14. The surface element according to claim 3, wherein each cell or pixel (100) has a multiplexed connection with the power supply, it means that each cell or pixel (100) of the two-dimensional array is powered by selecting respective row and column powering tracks corresponding to the (X, Y) position of the cell (100) in the two-dimensional array.

15. The surface element according to claim 14, wherein row and column powering tracks overlap insulated in the array thanks to positioning dielectric elements (7) preventing unwanted electric contacts at the crossover points of the row and column powering tracks.

16. The surface element according to claim 14, wherein a flat or surface-mounted (SMD) diode (80) is mounted on each pixel (100) output, so that no leakage current could pass to an adjacent pixel and improperly lighten in whole or in part the corresponding row and column.

17. The surface element according to claim 1, wherein the protective layer (5) is an encapsulating insulating layer obtained by serigraphy or spraying and made of dielectric material such as an oxide, a polymer or a ceramic-based material.

18. The use of one or more surface elements (1) according to anyone of the preceding claims, for providing an object or a person with a cover, sheet, blanket, casing or roofing capable of adapting the thermal signature of said object or person with the purpose of infrared stealthing, deception, camouflage, decoying or concealment.

19. The use of one or more surface elements (1) according to claim 18, wherein the plurality of heat dissipation elements (2, 20) selectively radiate a surface infrared pattern allowing to avoid the person or the object covered by said one or more surface elements (1) to be detected by an infrared detection device.

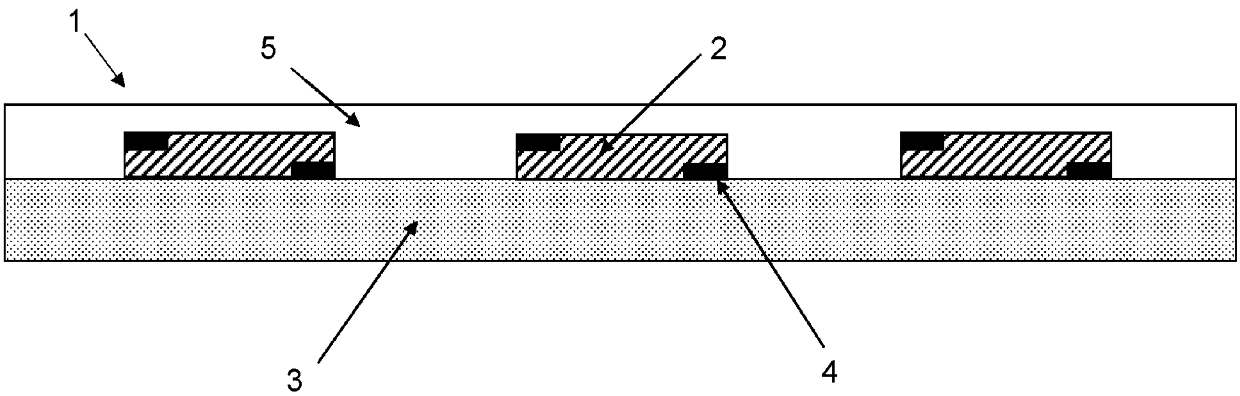

FIG. 1

3x3 independent pixels

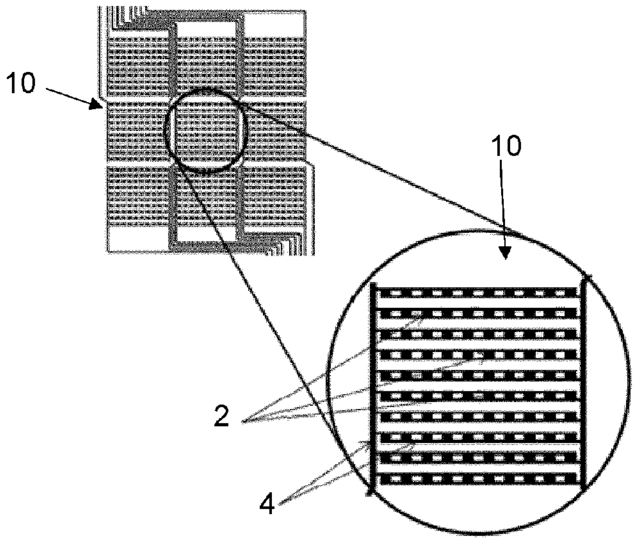

FIG. 2A

10x10 multiplexed pixels

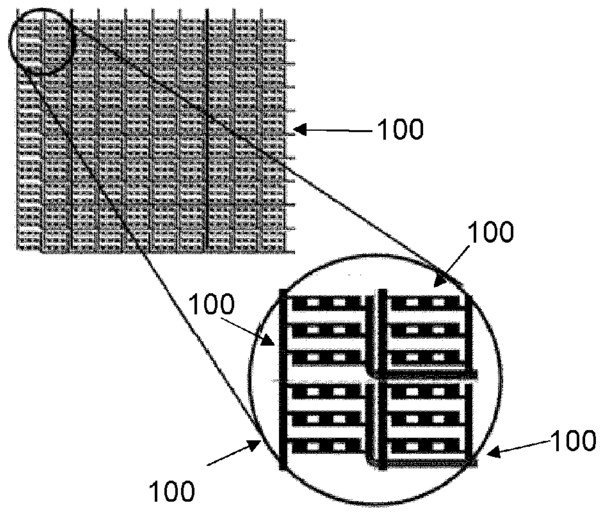

FIG. 2B

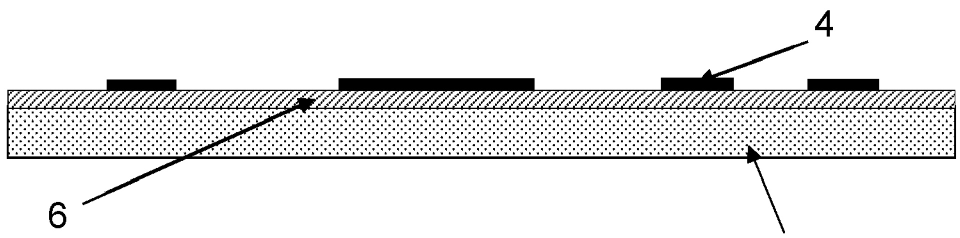

FIG. 3A

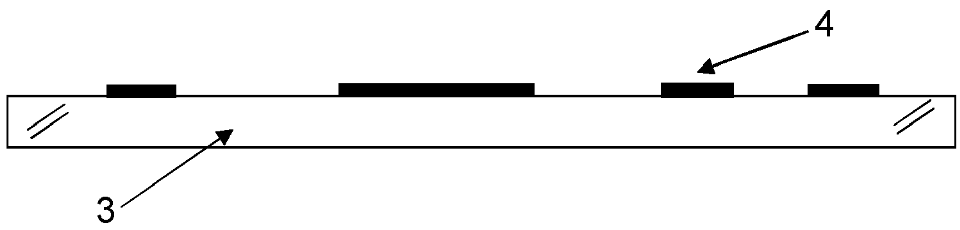

FIG. 3B

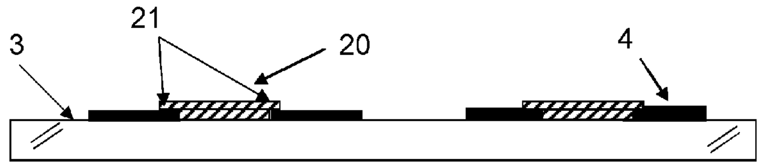

FIG. 4A

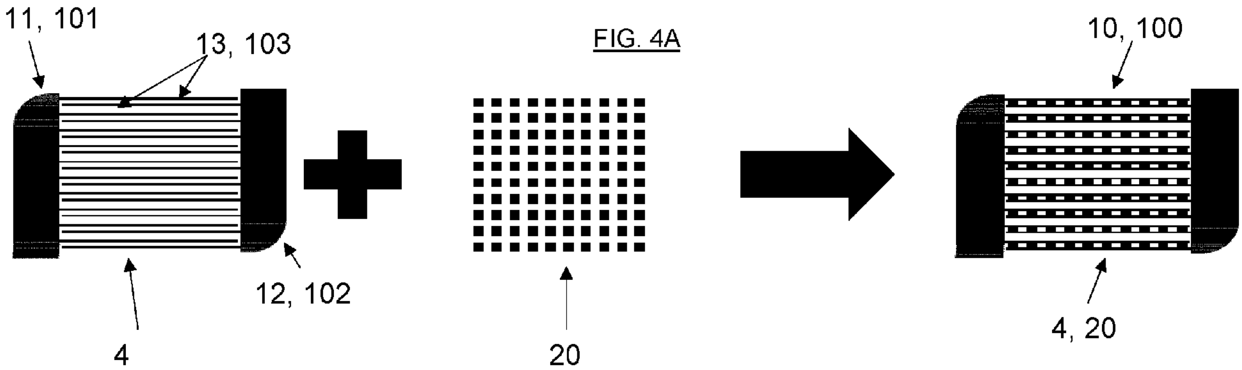

FIG. 4B

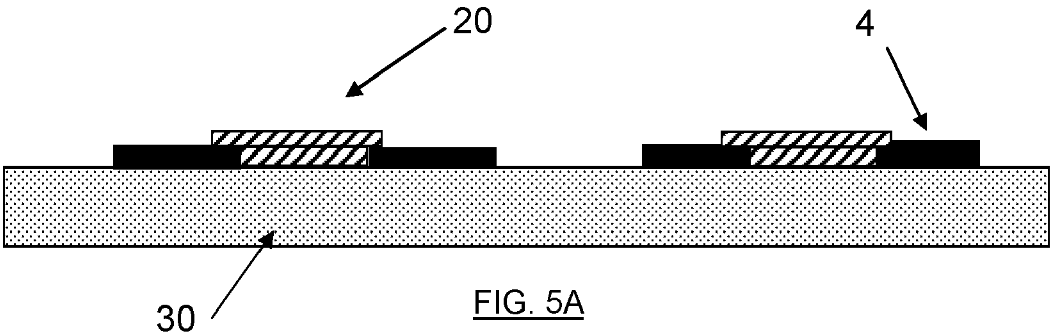

FIG. 5A

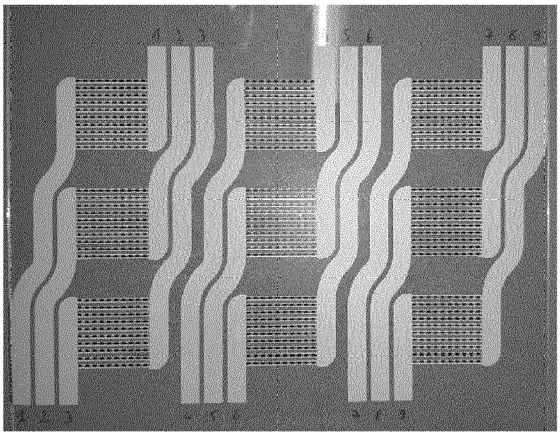

FIG. 5B

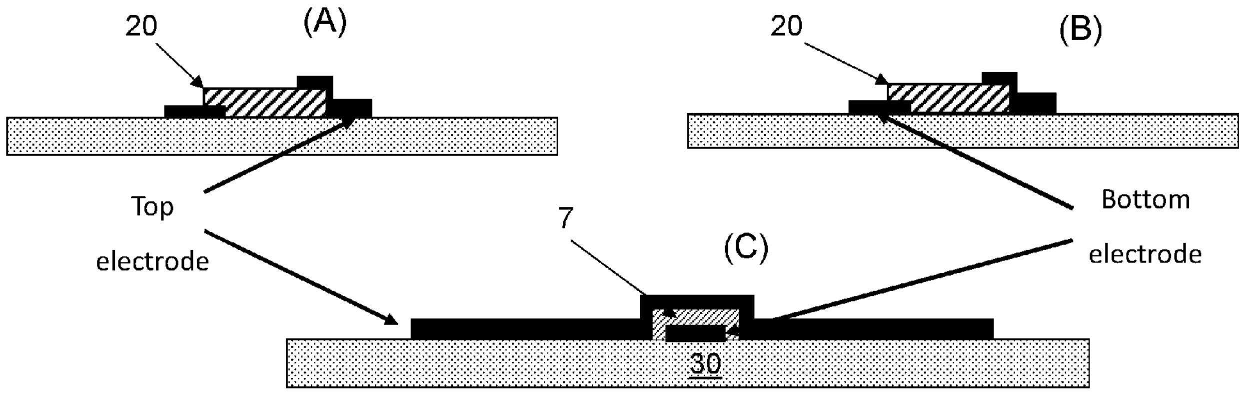

FIG. 6A

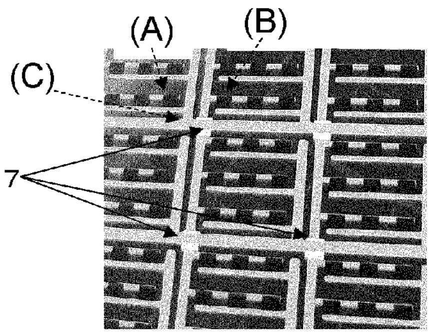

FIG. 6B

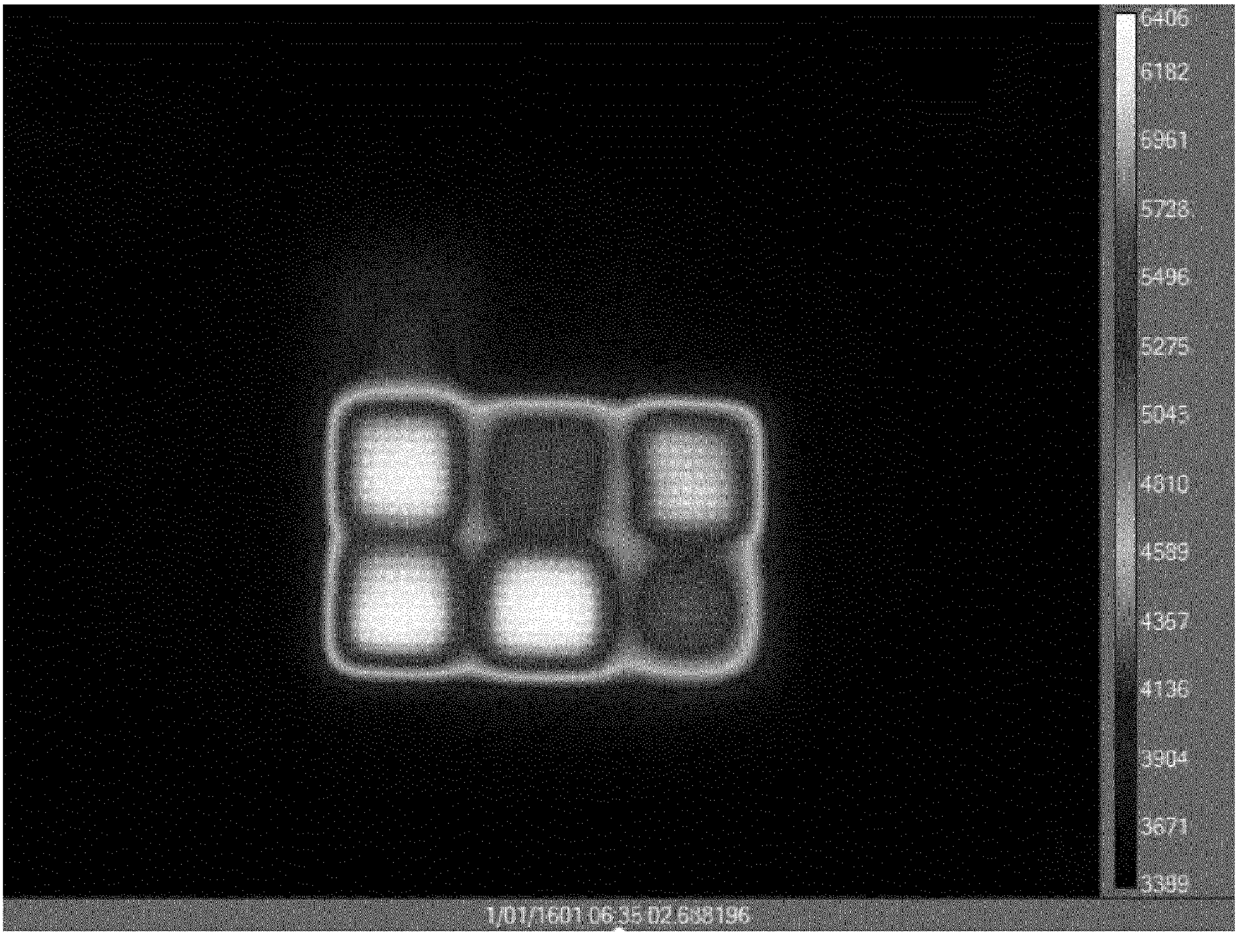
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FIG. 7

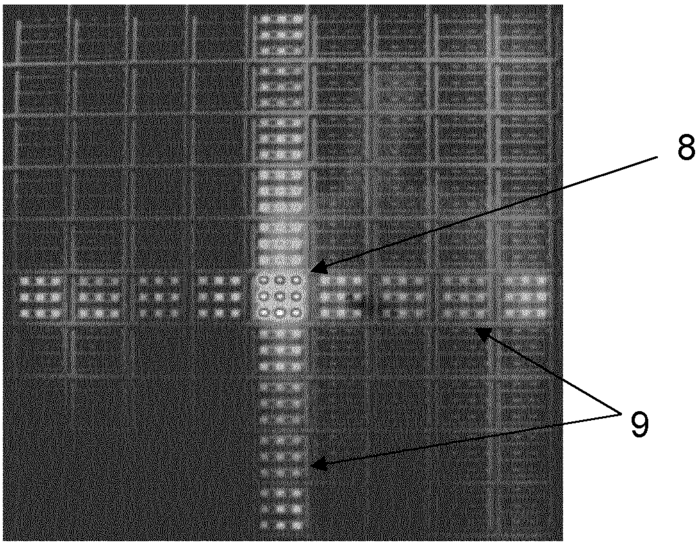

FIG. 8

FIG. 9

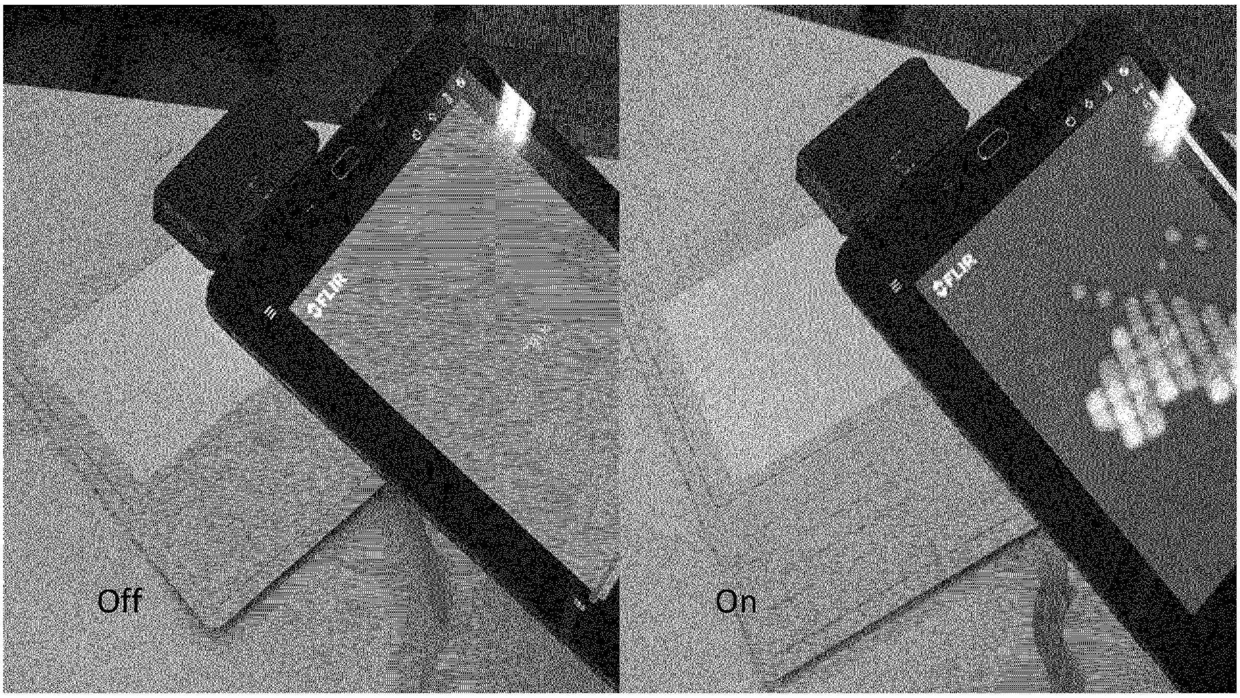

FIG. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 20 21 3140

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	27 May 2021	Menier, Renan

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27-05-2021

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