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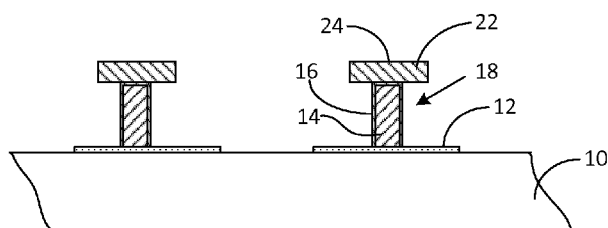


FIG 1a

(57) Abstract: A method of forming an elastic electrical connection includes forming a conductive elastic structure (18) on a conductive part of a substrate (10), applying an elastic layer (20) on the substrate (10) such that the elastic structure (18) is substantially embedded in said elastic layer (20), but with at least one surface extending out of the elastic layer, and attaching a first contact pad (22) on the one surface extending out of the elastic layer (20).



FLEXIBLE ELECTRONIC CONNECTIONS

This patent application claims the priority of the DK patent application No. 2018 70193, the disclosure of which is herewith incorporated by reference.

5

TECHNICAL FIELD

[0001] The present invention relates to a method of forming an elastic electrical connection and to an arrangement comprising an optoelectronic device.

10 BACKGROUND

[0002] With the development of electronics mounted on or integrated into a wide range of different products and materials, the need for flexible components, substrates and conductors have increased. Components such as integrated circuits, flexible electronic circuit boards, and LED filaments may, for example, be integrated into textiles, plastic, paper and other soft or
15 pliable materials in products like clothing, furniture, instrument panels and a wide range of other products. Consequently, there is a need for mounting and assembly technology with a high level of mechanical flexibility and an ability to retain this flexibility and functional reliability over time even while being subject to repeated bending and deformation.

[0003] Current solutions, such as balls and stub bumps do not provide sufficient flexibility for
20 many applications, for example LED filaments. Wire bonding is mechanically vulnerable and may easily be damaged.

[0004] Consequently there is a need for other alternatives that can improve flexibility and reliability for mounting of flexible electronics.

25 SUMMARY OF THE DISCLOSURE

[0005] In order to mitigate some of the problems associated with designs such as laterally mounted chips or flexible electronics, e.g. LED filaments integrated in textiles, the present invention provides a solution that can be used in applications that places high demands on the mechanical flexibility of the assembly technology and where known planar flexible structures
30 cannot be used to satisfaction. The technology described herein provides a spatially flexible contact arrangement during assembly as well as in use.

[0006] According to a first aspect of the invention an elastic polymer is provided with a metallic layer and with an additional contact surface.

[0007] According to a second aspect of the invention ductile metal structures that can absorb strong mechanical deformations and rotations are provided.
35

[0008] According to yet another aspect of the invention, a process sequence is provided for producing flexible connections and the process for attaching active components to these connections.

[0009] In some embodiments of the invention the method includes temporary embedding of
40 the connections in a removable material that after removal is replaced by a material with other properties. This enables manufacturing of components with advantageous properties.

[0010] A method of forming an elastic electrical connection in accordance with the invention may include forming a conductive elastic structure on a conductive part of a substrate, applying an elastic layer on the substrate such that the elastic structure is substantially embedded in said elastic layer, but with at least one surface extending out of the elastic layer, and attaching a first contact pad on the one surface extending out of the elastic layer.

[0011] Substantially embedded is here intended to mean that at the very least the top surface of the elastic structure is not covered by the elastic layer, and that if more of the elastic structure protrudes or extends out of the elastic layer the part that is embedded in the elastic layer should be sufficiently large to prevent forces and impacts that can reasonably be expected to be applied to the extending part during assembly from causing damage. The extending portion of the elastic structure could, for example, be anywhere in the range from 0% to 10% of the total length of the elastic structure.

[0012] In some embodiments of the invention the step of forming a conductive elastic structure includes providing an elastic material on the conducting part of the substrate, and providing a metallic layer on the outside of the elastic structure such that the metallic layer is electrically connected to the conductive part of the substrate. This may increase the elasticity and/or flexibility of the elastic structure compared with the alternative, which is to make the elastic structure from massive metal, which is also consistent with the principles of the invention.

[0013] The conductive elastic structure may include an elastic material on the conducting part of the substrate, and a metallic layer on the outside of the elastic structure, but in some embodiments it may be of massive metal. It may contain different metal portion attached together to form a shape capable of compensate for certain tension or stress exerted onto the connection.

[0014] In some embodiments of the invention the method further comprises providing an electrical component with a second contact pad, positioning the electrical component such that an exposed surface of the second contact pad is brought into contact with an exposed surface of the first contact pad, and removing the elastic layer. The component and the substrate may be may be bonded, soldered or welded together by their respective contact pads. In some embodiments of the invention the method further comprises providing an electrical component with a second contact pad, positioning the electrical component such that an exposed surface of the second contact pad is brought into contact with an exposed surface of the first contact pad, and removing the elastic layer. The component and the substrate may be held together mechanically in the correct position, or the surfaces of the contact pads may be bonded together.

[0015] In embodiments of the invention the first contact pad may be eccentrically positioned on the one surface of the elastic structure extending out of the elastic layer. The method may then further comprise bonding the first contact pad to the second contact pad using a metallic bond. The metallic bond may be provided using a method selected from the group consisting of: stub bumping, wedge bumping, and ball bumping.

[0016] By eccentrically positioning the metallic bond on the contact pad, but with an offset relative to a center axis of the elastic structure, force may be transmitted to the elastic structure with greater momentum, causing the elastic structure to absorb more of the force ap-

plied to the component relative to the substrate. The metallic bond should then cover only part of the respective contact surfaces of the first contact pad and the second contact pad.

[0017] According to other embodiments of the invention the attachment/bonding of the component to the substrate using an elastic connection provided by the invention, the elastic layer may be removed before an electrical component is provided. An electrical component with a contact pad may then be provided and positioned such that an exposed surface of the contact pad on the electrical component is brought into contact with an edge of the contact pad. This will enable the electrical component to be positioned substantially perpendicular to the substrate.

[0018] The electrical component may be a flip chip. In particular, the electrical component may be a LED flip chip, and the method may further comprise applying a reflective elastic layer containing a highly reflective material, such that the elastic structure and the contact pads are at least partly embedded in the reflective elastic layer while the LED flip chip extends out of the reflective elastic layer. The reflective elastic layer may be titanium oxide in a silicone matrix.

[0019] In embodiments where the electrical component is a LED flip chip, the method may further comprise applying a converting elastic layer containing a light converting material, such that the elastic structure, the contact pads and the LED flip chip are embedded in the reflective elastic layer. The converting elastic layer may be a phosphorous material in a silicone matrix.

[0020] In some embodiments the converting elastic layer is a combination of two sublayers, a first sublayer containing a first phosphorous material and applied on the substrate such that the elastic structure and at least part of the contact pads are embedded in the first sublayer, and a second sublayer containing a second phosphorous material and applied on the first sublayer such that the LED flip chip is embedded in the second sublayer.

[0021] In an arrangement, a substrate having at least two elastic contact stubs protruding from the surface of the substrate is provided. Each elastic contact stub comprises a conductive elastic structure and a contact pad and an optoelectronic device having a light emitting surface at least two contact pads, wherein the light emitting surface is substantially perpendicular to the surface of the substrate and the contacts pads are electrically contacted to the contacts pads of the elastic contact stubs.

[0022] Various embodiments of the invention are defined in the attached claims. Herein below examples will be discussed in further detail with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The exemplary embodiments are illustrated in the drawings.

[0024] FIG. 1a-d show embodiments of a connection element according to the invention;

[0025] FIG. 2a-f show a number of stages in a method of providing an elastic connection element and connecting a component;

[0026] FIG. 3 is a flowchart illustrating a method according to an embodiment of the invention;

[0027] FIG. 4a-b show assembly stages of another embodiment of the invention;

[0028] FIG. 5a-b show assembly stages according to yet another embodiment of the invention;

[0029] FIG. 6 shows an embodiment of the invention including a reflective layer;

[0030] FIG. 7 shows an embodiment of the invention including a converting layer;

5 [0031] FIG. 8 shows an embodiment of the invention including two different converting layers;

[0032] FIG. 9 shows an embodiment of the invention where a component is positioned perpendicularly to the substrate.

10 DETAILED DESCRIPTION

[0033] The following detailed description of embodiments refers to the accompanying drawings that show specific details of embodiments that provide examples of how the invention may be practiced. The various features in the drawings are not necessarily to scale. Instead, certain features may be shown exaggerated in scale or in a somewhat simplified or schematic
15 manner, wherein certain conventional elements may have been left out in the interest of exemplifying the principles of the invention rather than cluttering the drawings with details that do not contribute to the understanding of these principles.

[0034] It should be noted that, unless otherwise stated, different features or elements may be combined with each other whether or not they have been described together as part of the same embodiment below. The combination of features or elements in the exemplary embodi-
20 ments are done in order to facilitate understanding of the invention rather than limit its scope to a limited set of embodiments, and to the extent that alternative elements with substantially the same functionality are shown in respective embodiments, they are intended to be interchangeable. For the sake of brevity, no attempt has been made to disclose a complete description of all possible permutations of features.

[0035] In the present disclosure various terms will be used to refer to connections that are provided between different layers of a substrate, between contact pads on adjacent components that are in close proximity to each other, for example between a printed circuit board and a flip chip, and between contact pads on a substrate and corresponding contact pads on
30 surface mounted components provided on that substrate. Terminology used in the art include terms like "connections", "stubs", "balls", "bumps", "wires", etc. These terms are sometimes used in combination and sometimes alone, or in combination with terms describing material or process steps used to form them or bond them to each other. In the present disclosure the terms are not intended to be interpreted as implying limitations that have not been explicitly
35 included in the attached patent claims. In the following, the expressions "flexible" and "elastic" might be used in relation to contacts, stubs, FCB's, circuits boards or other elements. The expression refer to an element, which can absorb certain tension and stress without breaking or losing its intended purpose. A flexible or elastic element for example can bend in a certain direction without losing its electrical property. All the disclosed elements will exhibit a certain
40 elasticity as well as a certain flexibility, and use of one term should not be interpreted as implying an exclusion of the property described by the other term. As before the used terminol-

ogy is not intended to be interpreted as implying limitations that have not been explicitly included in the attached patent claims.

[0036] Relative terms like up, down, upward, downward, top, bottom, front, side, etc. may be used in this disclosure. Such terms refer to the relative position of features with respect to each other as illustrated in the drawings. These terms are not intended to be interpreted as absolute or as limiting on the scope of the invention.

[0037] The connections provided by the present invention provides a number of technical results that may be utilized in design of flexible electronic circuits. In particular, the elastic nature of the connections reduces mechanical stress on the chip contacts. They also allow the chips to be embedded in highly reflective or light converting polymer matrix systems. This may be utilized with SMT-mountable LED chips such as sapphire flip chips in flexible applications. The invention also provides a new assembly processes due to the elastic/flexible contact connections with these properties.

[0038] In the attached drawings same reference numbers are used to refer to the same or similar elements. In order to avoid cluttering the drawings, reference numbers are only used for once for elements that occur several times in the same drawing.

[0039] FIG. 1a shows a view of two connection elements according to an embodiment of the invention. The connection elements are mounted on a substrate 10 which may, for example, be a printed circuit board (PCB), a flexible circuit board and the like. The board may contain all kinds of circuitry (not shown), like for instance, control circuits, driver circuits and the like. In particular, the connection elements are provided on a conductive part of the substrate, for example on contact pads 12 provided on the surface of the PCB. The substrate contact pads 12 may be part of a conducting pattern on the PCB.

[0040] The connection elements according to this embodiment include an elastic material 14, for example a polymer, extending upward from the substrate contact pad 12 and covered by a metallic, electrically conducting layer 16. This part of the connection element is shown in a cross sectional view in order to show the elastic material 14 which otherwise would not be visible since it is covered by the metallic layer 16. The elastic material 14 covered by the metallic layer 16 makes up an electrically conducting elastic structure 18. On top of the elastic structure 18 there is provided a first contact pad 22 which may be a metallic disc. Metallic layer 16 electrically conducts pad 22 as seen in Figure 1. First contact pad 22 is attached to elastic structure 18 in a non-detachable way. As explained later various option are available to attached pad 22 to structure 18. First contact pad 22 is arranged centrally on structure 18 and has a contact surface 24, i.e. a surface which is substantially parallel with the substrate 10, and which is able to provide electrical contact with further electrical components resting on top of or attached to the connection element.

[0041] FIG. 1b shows a similar view, but in this embodiment the contact pad 22 is positioned eccentrically on top of the elastic structure 18 (which in this now shown in side view, not in a cross sectional view). It should be noted that while FIG. 1b can be interpreted as an alternative to the embodiment in FIG. 1a (with the second part centrally and eccentrically positioned on top of the first part, respectively), the two figures may also be interpreted as views of connection elements with eccentrically positioned second parts, viewed from the front and the side,

respectively. It should also be noted that with eccentrically mounted first contact pads 22 the increased momentum on the elastic structure 18 means that for some embodiments the elastic structure may be massive metal rather than a core of elastic material covered in a metallic layer. This will be discussed in further detail below.

[0042] FIG. 1c shows a perspective view of an embodiment where the contact pad 22 is centered on the elastic structure 18. FIG. 1d shows a perspective view of an embodiment where the contact pad 22 is eccentrically positioned on the elastic structure 18. The contact pad 22 in both cases is shaped as a cylindrical disk. Other embodiments for element 22 may provide different shapes, like for instance a half sphere, cone like structure, round top surface and the like.

[0043] FIG. 2 shows in a series of steps how connection elements according to the embodiment in FIG. 1 can be made and brought in contact with an additional component, for example an LED flip chip.

[0044] In a first step, shown in FIG. 2a, the elastic material 14 is provided on or directly adjacent to a conductive part of the substrate 10, for example a contact pad 12. Elastic material is a stub and protrudes above the surface. The stub of material 14 can be between several μm up to one or more mm. The substrate contact pad 12 may, for example, be part of a conductive pattern on a PCB, as described with reference to FIG. 1. In a next step, shown in FIG. 2b, the elastic material 14 is covered with a metallic layer 16. The elastic material 14 may be a suitable polymer, for example a polyamide or polyethylene, and the metallic layer may be copper, gold, silver, titanium or alloys thereof. The metallic layer 16 should be in electrical contact with the substrate contact pad 12. The application of the metallic layer may be done by evaporation or some other deposition method known in the art, such as chemical vapor deposition (CVD), sputtering, etc. Photo masks and etching techniques may be used in an intermediate step in order to prevent deposition of the metallic layer at undesired location.

[0045] As an alternative approach, the elastic material may be arranged on the substrate prior to actually creating the metal layer on the elastic material and the substrate. In such approach the metal layer and the contact pads and/or other electric connection on the surface may be generated in a single step.

[0046] As shown in FIG. 2c, after the metallic layer 16 has been provided, the substrate 10 may be covered with a layer of elastic polymer 20. This layer 20 is substantially flush with the top level of the first part of the connection element, but with at least the end surface of the metallic layer 16 extending out of the elastic layer 20. The elastic layer 20 serves to provide stability when in a next step, shown in FIG. 2d, a contact pad 22 is provided on top of the elastic structure 18. The contact pad 22 has an exposed contact surface 24 which constitutes the contact surface of the contact pad 22. Contact pad 22 can have a size which is significantly larger than the top area of stub 18. This provides larger tolerances in subsequent manufacturing steps. Its thickness is sufficiently large to provide certain mechanical stability when a chip is placed on the contact pad. It may be in the range of several $100\mu\text{m}$.

[0047] The elastic layer 20 may, for example, be silicone or polysiloxane. It should be noted that since this elastic layer is intended to provide support during assembly and will be re-

moved, its desired properties may vary from one embodiment or situation to another, and it may not be necessary for this layer to be elastic in all embodiments of the invention.

[0048] FIG. 2e shows how a component 25, which may for example be an LED flip chip, can be positioned or mounted on top of the connection element. The component 25 has its own contact pads 26 with contact surfaces matching those of the connection element mounted on the substrate 10. The presence of the layer of elastic polymer 20 serves to prevent damage to the connection elements during assembly. The contact surfaces of the contact pads 22, 26 may be bonded together using any suitable bonding technique, or attached together using soldering techniques, such as solder bump bonding. This will be discussed in further detail below.

[0049] After the component 25 has been suitably positioned and fastened the elastic polymer 20 may be removed, for example by using a suitable solvent such as acetone. The final result is shown in FIG. 2f which illustrates how electrical contact is provided between the substrate contact pad 12 and the component 25 through the metallic layer 16 covering the elastic material 14, and the metallic contact pads 22, 26. The metallized elastic material stub 14 allows substrate 10 to bend into one or more directions without breaking the connection between the contact pads 22 and pads 26 of the component. It also provides some compensation in case of different thermal behavior between the substrate and the component.

[0050] The process described above will now be summarized with reference to the flowchart illustrated in FIG. 3. In a first step S301 the elastic material 14 is formed on the conducting part 12 of the substrate 10. In a next step S302 a metallic layer 16 is provided on the outside of the elastic material 14, providing an elastic structure 18, and in contact with the conducting part 12 of the substrate 10. As already mentioned, in some embodiments the elastic material 14 may be unnecessary and the elastic structure 18 may be of metal only. The process then moves to step S303 where the elastic layer 20 is provided on the substrate 10 such that the elastic structure 18 is substantially embedded, but with at least an end surface extending outside the elastic layer 20.

[0051] A contact pad 22 can now be attached to the exposed surface of the elastic structure 18. This attachment can be done in any suitable metallic bonding technique known in the art. In some embodiments of the invention the contact pad 22 is eccentrically positioned on the elastic structure, as will be described in further detail below.

[0052] In some embodiments of the invention the process may halt at this point, or subsequent to removal of the elastic layer 20. This produces a substrate 10, for example a PCB with exposed connection elements that can be used later when the PCB receives additional components. This may be the case when the connection elements along with other components are mounted on a PCB in a production facility, but where the PCB is later sold or distributed in order to be mounted in a product such as a piece of clothing, an automobile, or a curtain at a later date.

[0053] In other embodiments (or at a later date in a different facility) the process continues in a next step S305 where a component with a corresponding contact pad is attached such that the corresponding contact pads are brought in contact with each other. It will be understood that although the process is described here with reference only to one connection ele-

ment and one corresponding contact pad on the component, in most cases there will be a PCB with a number of connection elements and a component (or another PCB) with a number of corresponding contact pads.

[0054] The step of attaching the component 25 (for example a flip chip) will be described below in further detail, and it may be performed in a number of different ways that are all consistent with the invention.

[0055] After the component 25 has been attached the elastic layer may be removed from the substrate. In some embodiment this step may be performed before the component 25 is attached, for example, as already described, because the step of attaching the component 25 will commence later at a different facility, where it may be difficult to remove the elastic layer 20, or because the component 25 (or other components or parts) are to be mounted such that they are brought in contact with the surface of the substrate 10 itself.

[0056] Additional steps may, of course, be performed after the process illustrated in FIG. 3 is complete. Some examples of such steps will be described below.

[0057] Turning now to FIG. 4a there is illustrated an embodiment where an elastic structure 18 with a metallic outer layer, or alternatively an elastic structure 18 made only of metal, is provided on a substrate contact pad 12, embedded in an elastic layer 20 and provided with an eccentrically positioned first contact pad 22. An electric component 25, which may for example be a flip chip with a corresponding second contact pad 26 is shown as it is about to be brought into contact with the exposed contact surface 24 of the contact pad 22. A metallic bond 27 is provided on the surface of the second contact pad 26. FIG. 4b shows the same components after they have been fully assembled and the elastic layer 20 has been removed. As can be seen from the drawing the center axis of the elastic structure 18 does not pass through the metallic bond 27. Instead the elastic structure 18 and the metallic bond 27 are attached to the first contact pad 22 on or towards opposing edges or sides such that if the component 25 is subject to a physical force causing it to move relative to the substrate 10, this motion will be absorbed by the elastic structure 18, which may bend or twist depending on the direction of the force. The offset between the elastic structure 18 and the metallic bond 27 allows the forces that work to move the component 25 relative to the substrate 10 to be absorbed to a larger degree than when the contact pads are centered as in the embodiment illustrated in FIG. 2.

[0058] FIG. 5 shows an embodiment which largely corresponds to the embodiment shown in FIG. 4. In this embodiment the metallic bond 28 is a solder ball, or another suitable ball bumping material such as gold, conductive epoxy (i.e. an epoxy filled with a metallic material such as silver), or copper. The contact pads may then be bonded together using bumping.

[0059] Generally speaking, the metallic bond 27, 28 can be a small solder or bonding bump, a small pellet or solder ball, or a metallic disc made from the same material as the contact pad 26, but with a different diameter. The pellet is attached and bonded to the component contact pad 26. When the component 25 is correctly positioned the metallic bond 27, 28 can be connected/bonded to the surface 24 of the first contact pad 22.

[0060] FIG. 6 shows an embodiment wherein, subsequent to the assembly steps described with reference to FIG. 3, a layer of elastic, highly reflective material 30 such as for example a

titanium oxide in a silicone matrix is deposited on the substrate 10 subsequent to the removal of the elastic layer. Thus the connection element can be embedded in an elastic layer which at the same time provides reflection of light generated by a LED flip chip component 25.

[0061] In FIG. 7 another embodiment is illustrated. In this embodiment, subsequent to the removal of the elastic layer, the connection element and a LED flip chip component 25 mounted on top of the connection elements are embedded in an elastic converter material 32, which may be a converter in a silicone matrix. The converter may, for example, be phosphor which is well known in the art for converting the color of light emitted from LED's. The elastic contact element 18 with their contacts pads are bonded or soldered to the contact pads 26 of the chip. Depending on the length of the stubs themselves, the overall arrangement can be bended up to a certain degree without the contact pads 26 being ripped away from the respective pads 22. In the given example illustrated here, the stubs can have an overall length of one or more mm.

[0062] FIG. 8 shows yet another embodiment where a flexible substrate 10, for example polyimide, is provided with a flexible conductive pattern 12 such as a copper foil circuit connected to connection elements which again are connected to a plurality of LED flip chips 25. The connection elements are embedded in a first flexible layer 32.1 with a first phosphorous material, while a second flexible layer 32.2 with a second phosphorus material is provided on top of the first flexible layer 32.1, embedding the LED flip chips 25. As a modification to this embodiment a reflective material 30 may be used instead of the first flexible layer 32.1.

[0063] Reference is now made to FIG. 9, which shows how connection elements according to an embodiment of the invention can be used to provide contact with contact pads 12 on a component 25, in particular an optoelectronic device that is mounted perpendicular to the substrate 10 and not parallel as described above. According to these embodiments, a connection element includes an stub elastic structure 18 constructed in accordance with the above description, i.e. either with an elastic material 14 covered by a metallic layer 16 or with a massive metallic structure. The selected method along with choice of materials and dimensions may depend on the size and weight of the component 25 and the extent to which the component 25 is expected to be exposed to forces, as a matter of design choice. The component can be an optoelectronic device such as a LED and the like. Arrangement in the form as illustrated in Fig. 9 enable the optoelectronic device to emit light substantially parallel to the substrate. The contact with the component contact pad 26 is made not with the top surface of the first connecting pad, but with the side surface 24. Again, the contact pads are bonded or soldered together or otherwise rigidly attached to each other. The arrangement is still flexible when being bended as the flexible stubs allow to be bended. Hence, such side emitter can be arranged on a flexible circuit board. In the embodiment illustrated in the drawing the component 25 is held as a result of connections according to the invention being provided on both sides of the component. This may be supplemented by bonding as well as adhesives.

[0064] While the examples of the different embodiments are shown with respect to an optoelectronic device, the flexible contact connection is not restricted to this purpose. For example different circuitry can be included in a chip and then arranged as a functional module

on a flexible substrate. The flexible connection provide the electrical contact and maintain a certain flexibility for bending and absorb tensions to a higher level compared to rigid contacts.

Reference list

	10	substrate	
5	12	conducting part	
	14	elastic material	
	16	metallic layer	
	18	elastic structure	
	20	elastic layer	
10	22	contact pad	
	24	side surface	
	25	component, Flip chip	
	26	contact pad	
	27, 28	metallic bond	
15	32	elastic layer	
		32.1, 32.1	elastic sublayers

CLAIMS

1. A method of forming an elastic electrical connection, comprising:
forming a conductive elastic structure (18) on a conductive part of a substrate (10);
5 applying an elastic layer (20) on said substrate (10) such that the elastic structure (18) is substantially embedded in said elastic layer (20), but with at least one surface extending out of the elastic layer (20); and
attaching a first contact pad (22) on said one surface extending out of the elastic layer (20).
- 10 2. A method according to claim 1, wherein the step of forming a conductive elastic structure (18) includes:
providing an elastic material (14) on said conducting part (12) of said substrate (10); and
providing a metallic layer (16) on the outside of the elastic structure (14) such that the metallic layer is electrically connected to the conductive part of the substrate (12).
- 15 3. A method according to one of the claims 1 or 2, further comprising:
providing an electrical component (25) with a second contact pad (26);
positioning said electrical component (25) such that an exposed surface of the second contact pad (26) is brought into contact with an exposed surface (24) of the first contact pad (22); and
20 removing the elastic layer (20).
4. A method according to claim 3, wherein said first contact pad (22) is eccentrically positioned on said one surface of the elastic structure (18) extending out of the elastic layer (20), the method further comprising:
25 bonding said first contact pad (22) to said second contact pad (24) using a metallic bond.
5. A method according to claim 4, wherein said metallic bond is provided using a method selected from the group consisting of: stub bumping, wedge bumping, and ball bumping.
- 30 6. A method according to claim 4 or 5, wherein said metallic bond is eccentrically positioned on said contact pad (22), but with an offset relative to a center axis of the elastic structure (18).
7. A method according to claim 6, wherein said metallic bond (27, 28) covers only part
35 of the respective contact surfaces of the first contact pad (22) and the second contact pad (26).
8. A method according to claim 1, further comprising the steps of:
removing the elastic layer (20);
40 providing an electrical component with a contact pad;
positioning said electrical component such that an exposed surface of the contact pad on the electrical component is brought into contact with an edge of said contact pad (22).

9. A method according to claim 8, wherein said electrical component is positioned substantially perpendicular to the substrate (10).

10. A method according to one of the claims 2-9, wherein said electrical component is a flip chip.

11. A method according to claim 10, wherein said electrical component is a LED flip chip, the method further comprising:

applying a reflective elastic layer containing a highly reflective material, such that the elastic structure (20) and the contact pads (22, 26) are at least partly embedded in the reflective elastic layer while the LED flip chip extends out of the reflective elastic layer (30).

12. A method according to claim 11, wherein said reflective elastic layer (30) is titanium oxide in a silicone matrix.

13. A method according to claim 10, wherein said electrical component (25) is a LED flip chip, the method further comprising:

applying a converting elastic layer (32) containing a light converting material, such that the elastic structure (20), the contact pads (24, 26) and the LED flip chip (25) are embedded in the converting elastic layer (32).

14. A method according to claim 13, wherein said converting elastic layer (32) is a phosphorous material in a silicone matrix.

15. A method according to claim one of the claims 13 and 14, wherein said converting elastic layer (32) is a combination of two sublayers, a first sublayer (32.1) containing a first phosphorous material and applied on the substrate (201) such that the elastic structure (202) and at least part of the contact pads (204, 207) are embedded in said first sublayer, and a second sublayer (32.2) containing a second phosphorous material and applied on the first sublayer such that the LED flip chip is embedded in the second sublayer (32.2).

16. Arrangement comprising:

- a substrate having at least two elastic contact stubs protruding from the surface of the substrate, each elastic contact stub comprising a conductive elastic structure (18) and a contact pad (22);
- an optoelectronic device (25) having a light emitting surface at least two contact pads (26), wherein the light emitting surface is substantially perpendicular to the surface of the substrate and the contacts pads (26) are electrically contacted to the contacts pads (22) of the elastic contact stubs.

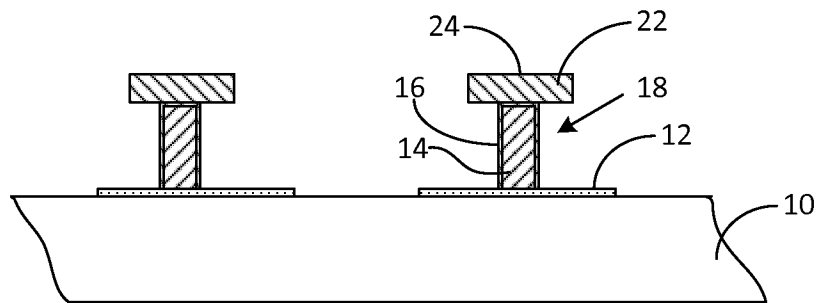


FIG 1a

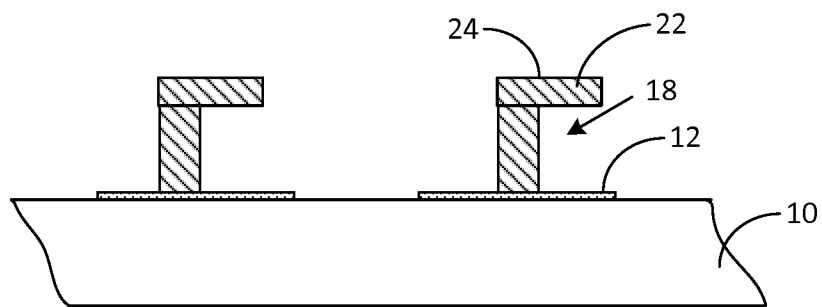


FIG 1b

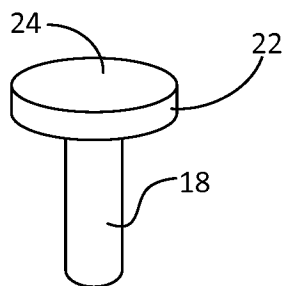


FIG 1c

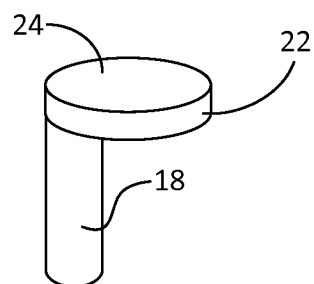


FIG 1d

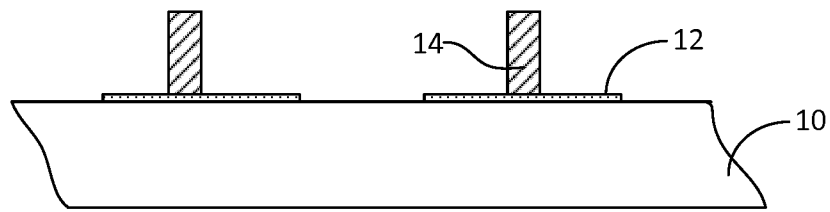


FIG 2a

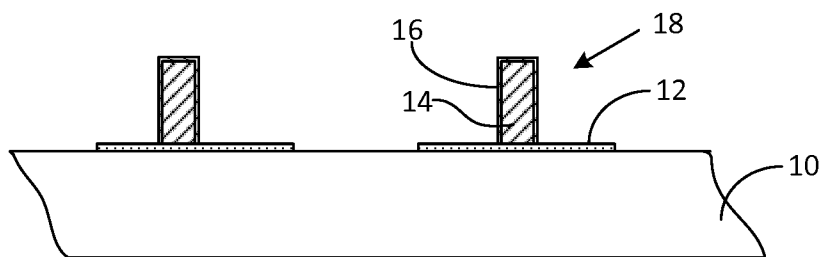


FIG 2b

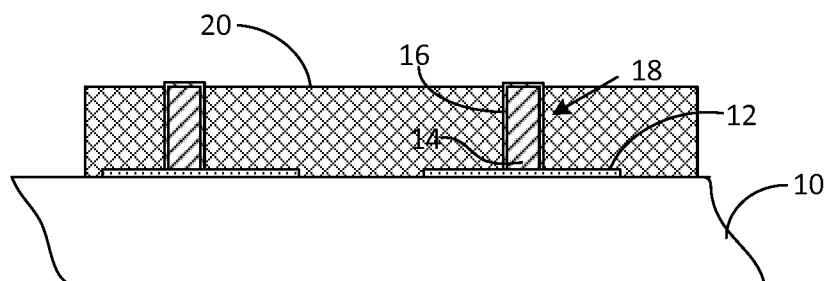


FIG 2c

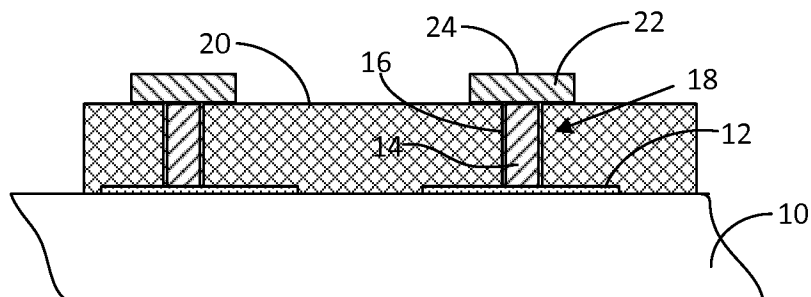


FIG 2d

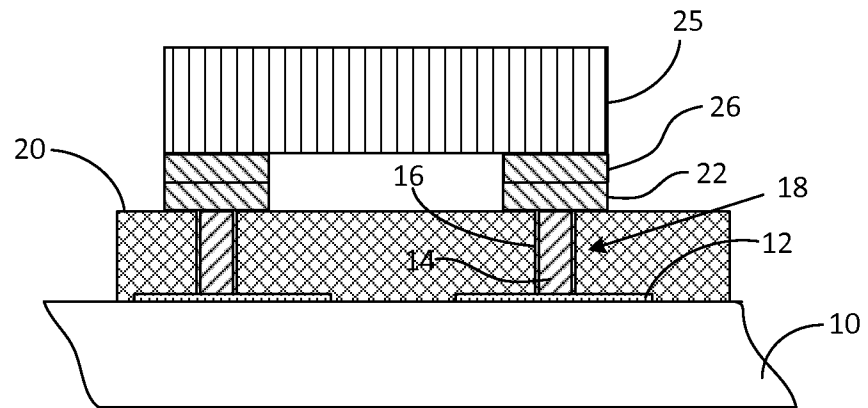


FIG 2e

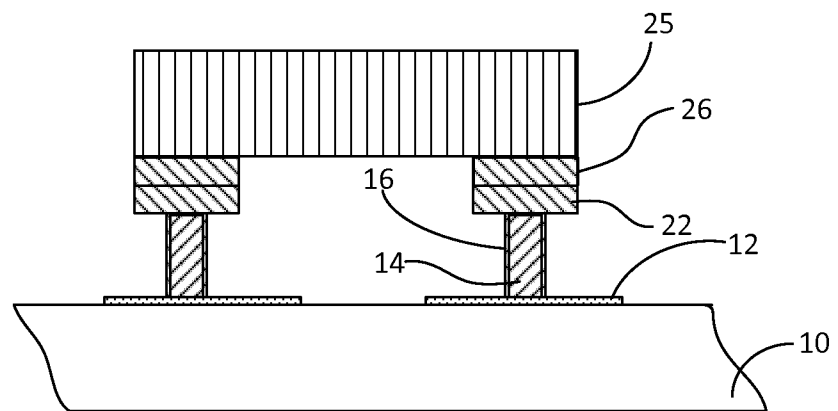


FIG 2f

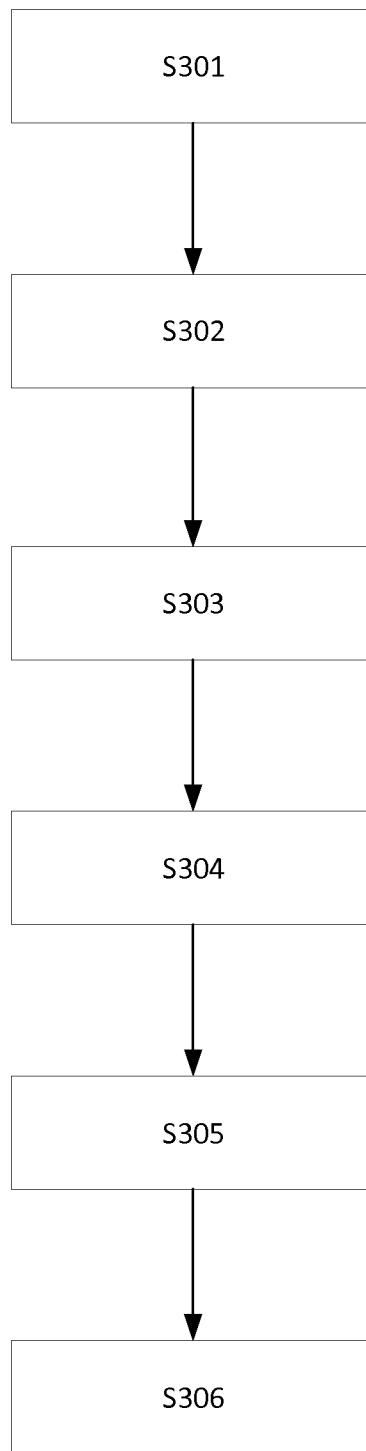


FIG 3

5/7

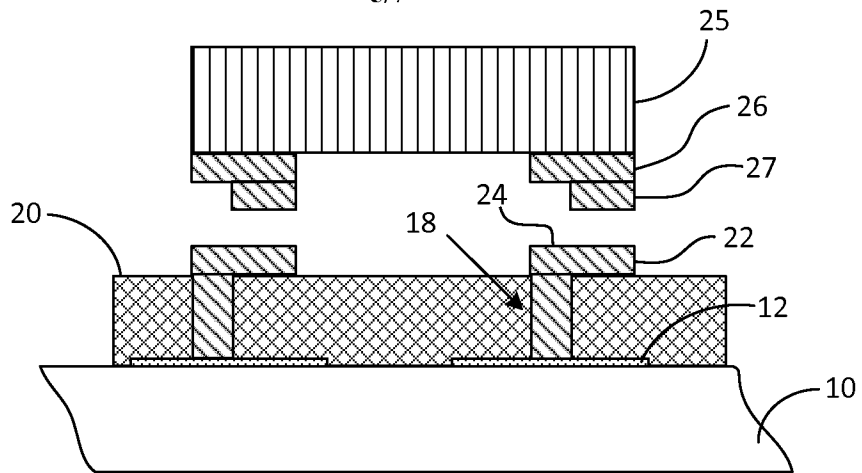


FIG 4a

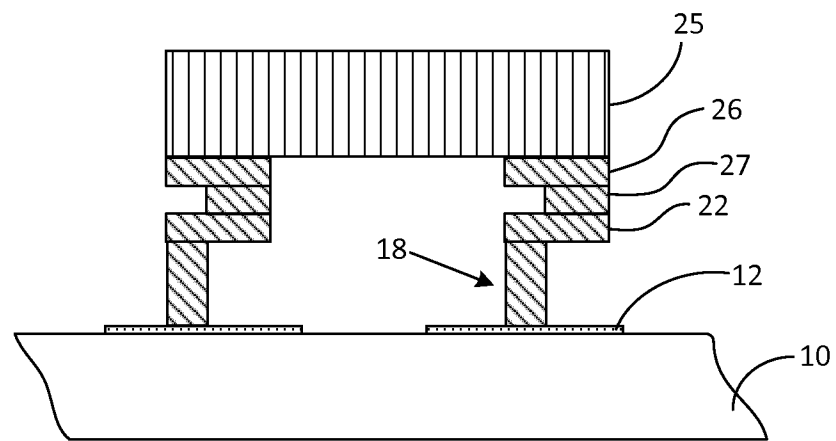


FIG 4b

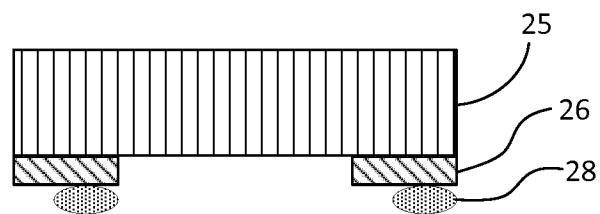


FIG 5a

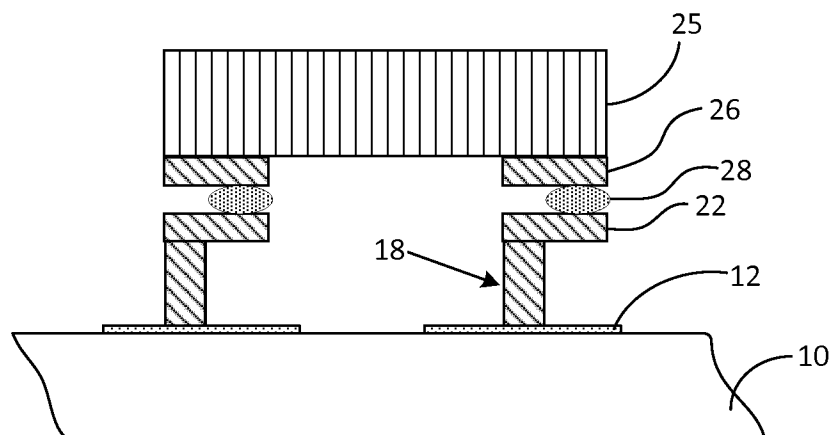


FIG 5b

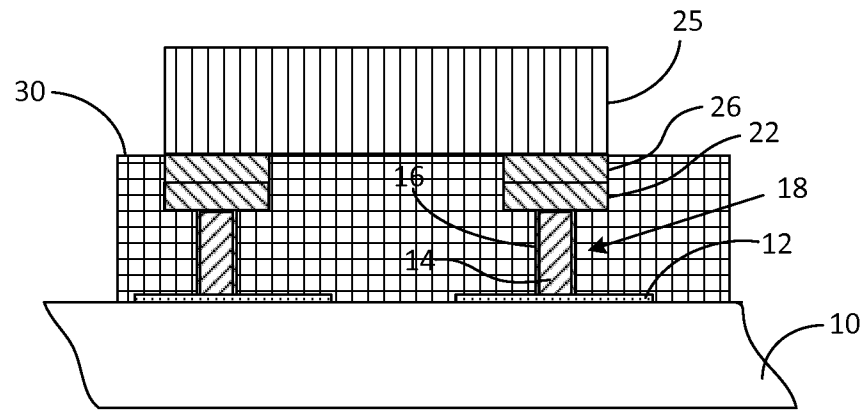


FIG 6

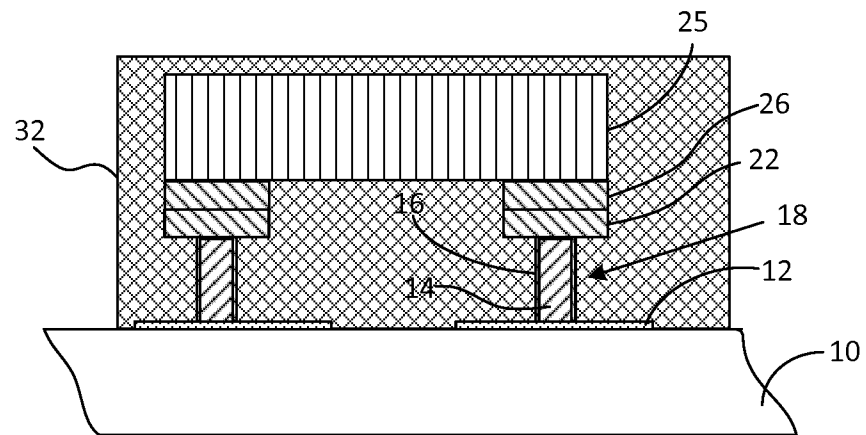


FIG 7

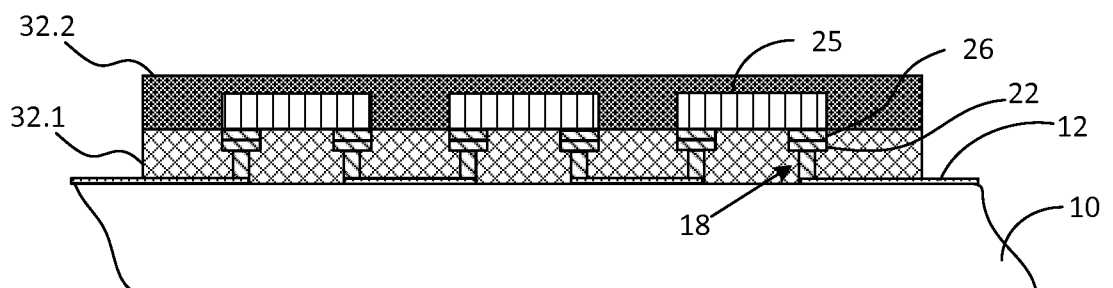


FIG 8

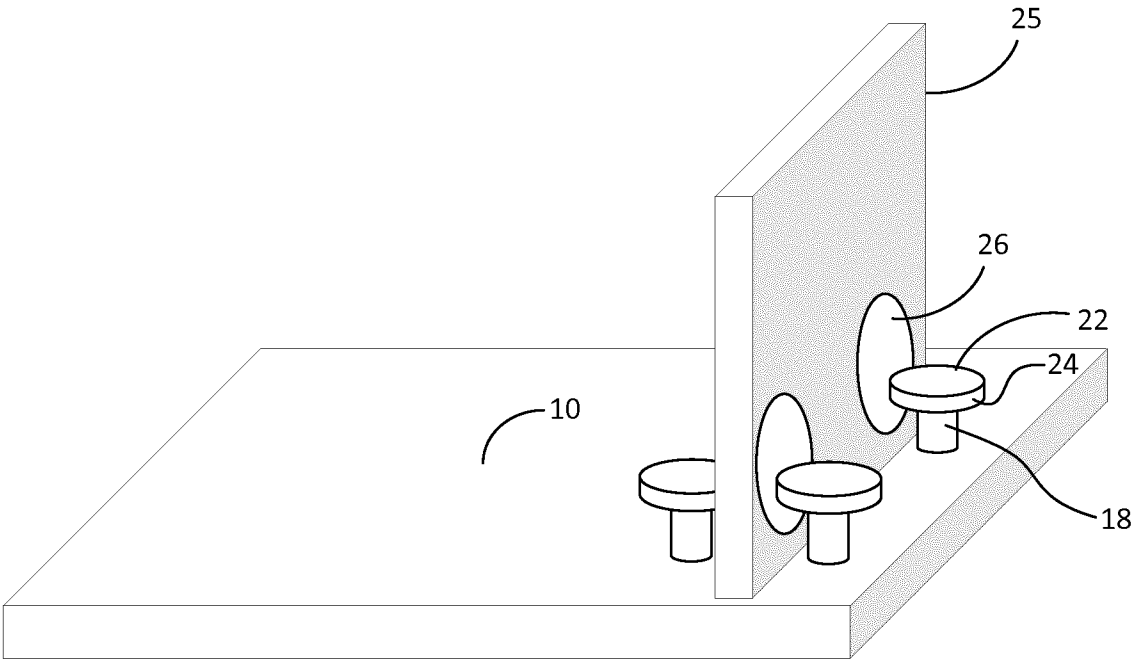


FIG 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/056865

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01L33/62 H05K1/18 H05K3/40 H01L23/00
ADD. H01L33/50 H05K1/11 H05K3/28

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01L H05K

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 2012/252168 A1 (NAH JAE-WOONG [US] ET AL) 4 October 2012 (2012-10-04) figures 2a-d	1-3, 10-12 13-15 4-7
X	----- US 2012/280386 A1 (SATO HIROAKI [JP] ET AL) 8 November 2012 (2012-11-08) paragraph [0073] figures 1,3	1,2
X	----- US 2012/313239 A1 (ZOHNI WAEL [US]) 13 December 2012 (2012-12-13) paragraphs [0044] - [0051] figure 1 ----- -/-	1



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

14 May 2019

Date of mailing of the international search report

17/07/2019

Name and mailing address of the ISA/

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Authorized officer

Gijsbertsen, Hans

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2019/056865

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2017/365760 A1 (RUAN JIABIAO [US] ET AL) 21 December 2017 (2017-12-21)	1,2
Y	paragraph [0105]	13-15
A	figures	3

A	US 6 110 823 A (ELDRIDGE BENJAMIN N [US] ET AL) 29 August 2000 (2000-08-29)	1
	the whole document	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2019/056865

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-7, 10-15

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-7, 10-15

Method of forming an elastic electrical connection comprising a conductive elastic structure, inter alia with a contact pad eccentrically positioned on an elastic structure.

2. claims: 8, 9, 16

Method of forming an elastic electrical connection comprising a conductive elastic structure wherein an electrical component is brought into contact with an edge of said contact pad

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2019/056865

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012252168 A1	04-10-2012	US 2012252168 A1	04-10-2012
		US 2014057392 A1	27-02-2014
		US 2014170816 A1	19-06-2014
		US 2014370662 A1	18-12-2014
		US 2015031173 A1	29-01-2015
US 2012280386 A1	08-11-2012	US 2012280386 A1	08-11-2012
		US 2013203216 A1	08-08-2013
US 2012313239 A1	13-12-2012	US 2012313239 A1	13-12-2012
		US 2015357304 A1	10-12-2015
		US 2017062318 A1	02-03-2017
US 2017365760 A1	21-12-2017	US 2017365760 A1	21-12-2017
		US 2019097108 A1	28-03-2019
US 6110823 A	29-08-2000	US 6110823 A	29-08-2000
		US 6336269 B1	08-01-2002