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Description

Field of the invention

[0001] The invention relates to the field of bio-medical applications. More particularly, the present invention relates to packaging methods for components, such as for example chips, for bio-medical in vivo applications and packaged devices thus obtained.

Background of the invention

[0002] Implantable chips are used in bio-medical in vivo applications e.g. for performing controlling or monitoring functions. Such implantable chips should be packaged to protect the body from leakage of harmful products from the chip towards the body, or from other harmful influences such as mechanical friction of the implanted chip in the body. Furthermore, the chip should be protected from influences from the body, such as diffusion from bio-products from the body into the chip, resulting in damaging or improper functioning of the chip.

[0003] A known way of packaging chips for medical applications takes care of the required bi-directional protection, by placing the chip in a 'big box', often a Titanium housing surrounding a chip mounted on a printed circuit board PCB. In this known way of packaging, the package is large in comparison with the size of the original chip, requiring larger incisions during implantation, thus resulting in a more extensive wound healing and inflammation process. Furthermore, the larger the implant, the larger the fibrous encapsulation may be resulting in a higher risk on local tissue irritation for the patient during the lifetime of the implant. When applying the 'big box' packaging technique, the chip itself often also is packaged with an individual standard package, before it is mounted on the PCB.

[0004] By way of illustration, cross sectional views of two types of conventional chip packages are shown. In a first example in FIG. 1a, a chip 100 having an individual package 110 is shown whereby metal wires 120 are provided for connecting the individually packaged chip to the PCB 130. The device is furthermore packed completely in a device housing 140. As the standard individual chip packaging is not bio-compatible, the second packaging, referred to as the device housing 140 here definitely is required resulting in a much higher total packaging cost. In FIG. 1b, packaging of a chip 100 that is mounted directly on the PCB whereby only a single packaging is present, being the device housing 140. In this case the chip is not packaged individually and there is a risk of chip contamination or damage, resulting in device malfunctioning. The individual packaging of chips as illustrated by FIG. 1a, has the disadvantage of being a time consuming and expensive process, as all chips conventionally are packaged individually.

[0005] US 7,371,693 B2 describes a glass-based device wherein chip sized packaging is performed by sep-

aration of individual dies using wet etching of a groove between dies. The wet etching furthermore has a rounding effect for the sharp edges of the dies. The document furthermore describes the provision of a protection film.

5 The protection film is not provided to hermetically encapsulate the device.

[0006] A common encapsulation method can be found in document US 6 482 730 B1.

10 Summary of the invention

[0007] It is an object of embodiments of the present invention to provide good methods and systems for packaging devices e.g. for bio- or bio-medical-applications and packaged devices thus obtained. It is an advantage of embodiments according to the present invention that the packaged devices can be small, e.g. substantially of a similar size as or only slightly larger than the original device size itself. It is an advantage of embodiments according to the present invention that a biocompatible device, e.g. a biocompatible chip, can be obtained, that is provided with a reliable diffusion barrier. It is an advantage of embodiments according to the present invention that a safe solution for preventing diffusion can be obtained. The latter can amongst others be obtained by providing a device encapsulation composed out of stacked layers fully encapsulating the device, at least one of the layers being made of a bio-compatible material.

20 [0008] It is an advantage of embodiments according to the present invention that the packaging method can be applied to substrates comprising a plurality of components, e.g. full semiconductor wafers with a plurality of dies, so that part of the encapsulation process in the packaging process can be performed simultaneously for the plurality of components. The latter results in a decrease in cost and effort, e.g. in a cheaper production process, especially for chip fabrication, as a large number of dies may be present on a substrate.

30 [0009] It is an advantage of embodiments according to the present invention that at least part of the encapsulation can be performed in a clean environment, e.g. in clean room conditions after chip processing, and that in this way contamination and/or damage can be avoided. The latter is possible as providing the encapsulation is performed with conventional clean-room deposition or coating techniques.

40 [0010] It is an advantage of embodiments according to the present invention that good step coverage can be obtained for the encapsulation resulting in uniform thickness of the encapsulation, assisting in obtaining a reliable diffusion barrier. It furthermore is an advantage that good step coverage can be obtained even when using low temperature deposition processes.

50 [0011] It is an advantage of embodiments according to the present invention that a packaged device with smooth edges can be obtained, thus decreasing the risk on local tissue irritation upon implantation of the device.

[0012] It is an advantage of embodiments according to the present invention that one or more of these advantages can be obtained in combination with a packaging technique that is substantially material independent, i.e. independent of the substrate or component materials used.

[0013] The above objective is accomplished by a method and device according to the present invention.

[0014] The present invention relates to a method for packaging a device, the method comprising obtaining a component on a substrate, separating the component and a first part of the substrate from a second part of the substrate using at least one physical process inducing at least one sloped side wall on the first part of the substrate, and providing an encapsulation for the component. With sloped side wall reference may be made to a side wall that is oriented not perpendicular to the substrate surface. It is an advantage of embodiments according to the present invention that packaged devices can be obtained that are suitable for bio-medical applications. It is an advantage of embodiments according to the present invention that the packaged devices may induce little or no irritation because sharp edges are avoided in the packaged device. It thereby is an advantage of embodiments according to the present invention that the packaging method can be applied substantially independent of the materials used in the chip or as substrate. In this way, such packaging may be used for substantially all types of chip materials and/or all types of substrate materials. It is an advantage of embodiments according to the present invention that a good step coverage of the encapsulation can be obtained. Using the at least one physical process may comprise at least dicing using a blade with substantially sloped blade surfaces so as to create a recess or cut with sloped side walls. It is an advantage of embodiments according to the present invention that a simple mechanical technique can be applied for performing the separating process. Alternatively, the physical process may include for example laser cutting. Generating the sloped blade surface may then be obtained by controlling the laser beam profile or laser beam orientation.

[0015] Separating may comprise using a physical process inducing a sloped surface in the first part of the substrate at the side of the substrate where the component is present on the substrate.

[0016] Separating and providing an encapsulation may comprise providing a recess in a top surface of the substrate using the at least one physical process inducing at least one sloped side wall so that the recess comprises at least one sloped side wall, and depositing a first capping layer covering a top surface of the substrate and at least part of the recess. It is an advantage of embodiments according to the present invention that part of the encapsulation, i.e. the provision of the first capping layer, can be performed to the full substrate which may comprise a plurality of chips, thus allowing part of the encapsulation process to be performed simultaneously and ef-

ficiently for a plurality of chips. It is an advantage of embodiments according to the present invention that a good coverage can be obtained by the capping layers. Providing a recess in a top surface of the substrate may comprise applying a first dicing process to the top surface with a blade providing a cut with side walls substantially perpendicular to the substrate top surface, and applying at least one second dicing process to the top surface with a blade providing a cut with sloped side walls substantially non-perpendicular to a surface of the substrate, the first dicing process and the second dicing process being performed at substantially the same location on the substrate surface. It is an advantage of embodiments according to the present invention that the double dicing technique allows to make the edges of the packaged chip less sharp, resulting in reduction of irritation or damaging of tissue after implantation.

[0017] Separating may comprise using a second physical process inducing a sloped surface in the first part of the substrate at the side of the substrate opposite to the side of the substrate where the component is present on the substrate. It is an advantage of embodiments of the present invention that a packaging can be obtained whereby all corners of the packaged chip can be rounded.

[0018] Separating and providing an encapsulation furthermore may comprise thinning the bottom surface of the substrate, e.g. at least at a position substantially opposite to the recess at the top surface of the substrate, so that a cut is formed and the first part of the substrate is separated from the second part of the substrate, and depositing a first capping layer covering the bottom surface and at least part of the area corresponding with the walls of the cut at the bottom surface of the substrate. In embodiments according to the present invention, the provision of the recess at the bottom surface of the substrate may be made using any suitable technique. It is an advantage of embodiments according to the present invention that a good coverage can be obtained by the capping layers.

[0019] After thinning the bottom surface of the substrate, the method may comprise using a second physical process inducing at least one sloped side wall so that the edge at the bottom surface comprises a sloped side wall. In advantageous embodiments according to the present invention, all corners of the resulting encapsulated chip can be less sharp or unsharp, i.e. corners being substantially less sharp than 90°, resulting in a reduced risk of irritation after implantation.

[0020] For thinning the bottom surface of the substrate, the substrate may be fixed with the top surface to a carrier before thinning and the carrier may be removed after inducing at least one sloped side wall at the bottom surface. It is an advantage of embodiments according to the present invention that at least part of the packaging process can be performed simultaneously for a plurality of chips so that the number of steps in the packaging process involving individual handling of chips can be reduced.

[0021] The method furthermore may comprise provid-

ing a further encapsulation layer after said separating. It is an advantage of embodiments according to the present invention that encapsulation can be formed from at least two layers, allowing an encapsulated chip with limited size, i.e. only slightly larger than the chip integrated on the substrate. It is an advantage of embodiments according to the present invention that a good coverage and hermiticity can be obtained.

[0022] Prior to providing a further encapsulation layer, an additional cleaning step may be performed.

[0023] The method may comprise applying a protective top coating for protecting the chip before using the at least one physical process inducing a sloped surface.

[0024] The method may comprise applying a plasma treatment for removing surface damage after using the at least one physical process inducing a sloped surface.

[0025] The method may comprise applying a plasma treatment for removal of surface damage after the thinning of the wafer. Providing an encapsulation for a component may comprise depositing an encapsulation layer using two subsequent and distinct depositions of sub-layers, the sub-layers forming the encapsulation layer. It is an advantage of embodiments according to the present invention that the number of pinholes throughout the full encapsulation layer can be reduced.

[0026] The present invention also relates to a device for bio-medical applications, the device comprising a component present on a substrate, wherein the device comprises at least one sloped side wall induced using a physical process.

[0027] The present invention also relates to a device for bio-medical applications, the device comprising a component on a substrate, the device having a hermetic bio-compatible packaging comprising a first capping layer and a further encapsulation layer. It is an advantage of embodiments according to the present invention that packaged devices can be obtained with a good coverage by the encapsulation material and with a hermetic packaging, thus avoiding diffusion from and towards the device after implantation. The bio-compatible packaging may consist of the first capping layer and the further encapsulation layer. It is an advantage of embodiments according to the present invention that packaged devices can be obtained whereby good packaging is obtained using only two encapsulation layers, making the packaging technique relatively efficient. It is an advantage of embodiments according to the present invention that hermetic packaging is obtained for individual dies.

[0028] The first capping layer and the further encapsulation layer may be positioned in solid contact with the component on the substrate. It is an advantage of embodiments according to the present invention that packaged devices can be obtained that are only slightly larger than the chip integrated on the substrate itself. With solid contact reference may be made to direct contact with the chip integrated on the substrate or to indirect contact whereby only solid materials, e.g. other layers, are present in between. The packaging may be provided as

a stack of layers.

[0029] The present invention also relates to a biocompatible system, the biocompatible system comprising at least one packaged device as described above. The biocompatible system may comprise at least two packaged devices and a global encapsulation.

[0030] The present invention also relates to a method for packaging a device, the method comprising obtaining a component present on a substrate and providing a hermetic bio-compatible packaging by providing a first capping layer and a further encapsulation layer in solid contact with the component present on the substrate. Providing a first capping layer may comprise providing at least part of a first capping layer before cutting the chip integrated on a first part of the substrate from a remainder part of the substrate.

[0031] In some embodiments, bi-directional diffusion barrier are obtained whereby no leaching of bodily fluids into the implant occurs, and no diffusion of harmful components of the implant into tissue occurs. It is furthermore an advantage of embodiments of the present invention that the devices can remain functional after packaging and after implantation.

[0032] Particular and preferred aspects of the invention are set out in the accompanying independent and dependent claims. Features from the dependent claims may be combined with features of the independent claims and with features of other dependent claims as appropriate and not merely as explicitly set out in the claims. The improvements in the packaging methods provided by embodiments of the present invention result in better and/or more reliable bio-medical implantable devices.

[0033] Embodiments of the invention will now further be discussed in the detailed description in conjunction with the drawings. The drawings are only schematic and are non-limiting. In the drawings, the size of some of the elements may be exaggerated and not drawn on scale for illustrative purposes. Any reference signs in the claims shall not be construed as limiting the scope. In the different drawings, the same reference signs refer to the same or analogous elements.

Brief description of the drawings

[0034]

FIG. 1a and FIG. 1b illustrates two cross sectional views of chip packages for implantable chips as known from prior art.

FIG. 2 illustrates an exemplary flow chart for a packaging method according to a particular embodiment of the present invention.

FIG. 3 illustrates different intermediate results of a packaging method according to a particular embodiment of the present invention.

FIG. 4 illustrates different intermediate results of a packaging method according to another particular embodiment of the present invention.

FIG. 5A illustrates the use of a differently shaped dicing blade and the corresponding intermediate results in a packaging method according to an embodiment of the present invention.

FIG. 5B illustrates scanning electron microscope images of cuts made with a straight blade, with a bevel blade and by combination of cutting with a straight and with a bevel blade, as can be used in embodiments of the present invention.

FIG. 6 illustrates the result of a packaging method with additional feedthrough processing step, according to particular embodiments of the present invention.

FIG. 7 illustrates an example of a packaged device according to an embodiment of the present invention.

FIG. 8 to FIG. 10 illustrate different hermetic implantable systems comprising different packaged devices, according to embodiments of the present invention.

FIG. 11 illustrates a hermetic implantable system with further embedding, according to an embodiment of the present invention.

FIG. 12 illustrates SEM pictures illustrating step coverage as can be obtained using a method according to an embodiment of the present invention.

FIG. 13 illustrates biocompatibility tests for packaged components illustrating features and advantages of embodiments according to the present invention.

Detailed description of illustrative embodiments

[0035] In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention and how it may be practiced in particular embodiments. However it will be understood that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures and techniques have not been described in detail, so as not to obscure the present invention. While the present invention will be described with respect to particular embodiments and with reference to certain drawings, the reference is not limited hereto.

[0036] Furthermore, the terms first, second and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequence, either temporally, spatially, in ranking or in any other manner. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described or illustrated herein. For example, it is to be noticed that the step of separating and of providing an encapsulation may be interchanged in order or may comprise a number of sub-steps that intermix with each other, i.e. the order of the steps may

be interchanged, the order of the sub-steps within one step may be interchanged or the order of the sub-steps within different steps may be interchanged as appropriate. In the following description, by way of illustration, a number of examples and embodiments with interchanged steps will be discussed, the present invention not being limited thereto.

[0037] Moreover, the terms top, bottom, over, under and the like in the description and the claims are used for descriptive purposes and not necessarily for describing relative positions. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other orientations than described or illustrated herein.

[0038] It is to be noticed that the term "comprising", used in the claims, should not be interpreted as being restricted to the steps or elements listed thereafter; it does not exclude other elements or steps. It is thus to be interpreted as specifying the presence of the stated features, integers, steps or components as referred to, but does not preclude the presence or addition of one or more other features, integers, steps or components, or groups thereof. Thus, the scope of the expression "a device comprising A and B" should not be limited to devices consisting only of components A and B. Where reference is made to the term consists of, the latter implies that no other elements are present.

[0039] Where in embodiments of the present invention reference is made to biocompatible, reference is made to the ability of a medical device to perform its intended function, with the desired degree of incorporation in the host without eliciting any undesirable local or systemic effects in that host. The medical device thereby may be positioned in the host with reduced or minimal interaction that adversely affects device. The biocompatibility demands will depend on the type of contact between the medical device and the host, the position of the implant and the period the implantable device will stay in the host.

[0040] In a first aspect, the present invention relates to a method for packaging a device. The device thereby typically may be a component on a substrate. One type of such components may be integrated circuits, also referred to as dies, including the back-end-of-line process. Another example of such components may be micro electromechanical systems (MEMS), including 0-th level packaged MEMS, thin film capped MEMS, etc. The MEMS devices may for example be passive components, actuators, sensors, etc. A further example of such components may be micro-fluidics devices. Still another example is a battery, e.g. a battery integrated in silicon, e.g. a rechargeable battery. The substrate may be any suitable substrate such as for example a semiconductor substrate, e.g. a silicon substrate, an electrically insulating substrate, a glass substrate, a polymer substrate, and where allowable an electrically conducting substrate such as for example a metal. The method is especially suitable for packaging of devices, such as e.g. chips, for

bio-medical applications, e.g. for making implantable devices for in-vivo applications. The method according to the present invention comprises obtaining a component on a substrate. The latter may include manufacturing such a component on a substrate, as can be done using conventional techniques, or obtaining such components on a substrate from the shelf. The method furthermore comprises separating the component and a first part of the substrate from a second, remainder, part of the substrate using at least one physical process thus inducing at least one sloped side wall on the first part of the substrate. A sloped side wall thereby may be a wall or part thereof being non-perpendicular to the top surface of the substrate. Such physical processes may include dicing, laser cutting, etc. The presence of sloped side walls will result in less sharp edges in the packaged device, such that there is less risk on injury or irritation upon and after implantation. The packaged device may be part of a larger system in which a number of devices are grouped, optionally electrically connected, as will be described further. The larger system may be packaged using a second packaging. In such cases, less sharp edges of the packaged device also may result in an increased reliability of the second packaging for the larger system. The method also comprises providing an encapsulation for the component and the first part of the substrate. The encapsulation can be composed out of one or more levels of packaging. According to some embodiments of the present invention, these levels of packaging consist out of layers of materials, e.g. bio-compatible materials. Typical materials that could be used for packaging, as single layer or stack of layers, may include polyurethane, polycarbonate urethane, silicone, silicone-polyester-urethane, polyimide, durimide (photo-definable polyimide), parylene, cyclic olefin polymer (COP), cyclic olefin copolymer (COC), polymethyl methacrylate (PMMA), polyether ether ketone (PEK), polyphenylene, polysulfone, polyphenylsulfone, embodiments of the present invention not being limited hereto. Although in the present illustration the example is given by a packaging of two levels, the present invention is not limited thereto and more packaging levels may be added. The use of several stacked layers as packaging can be a safe solution to ensure total encapsulation and to obtain a reliable diffusion barrier. Embodiments using stacked layer encapsulation results in smaller packaged devices, which results in easier wound healing and less risk on local tissue irritation upon implantation. As indicated above, separating and providing an encapsulation may be intermixed.

[0041] By way of illustration, an embodiment of an exemplary method for packaging will now be described with reference to FIG. 2, the present invention not being limited thereto. The packaging method 200 indicates standard and optional steps in the packaging method. Reference is also made to FIG. 3 illustrating different intermediate results as can be obtained using a packaging method as shown in FIG. 2.

[0042] In a first step 210, a device is obtained compris-

ing at least one component 410 on a substrate 420. Obtaining such a device may be performed by either obtaining a ready made device or by processing a component 410 on the substrate 420. The component 410 may be any type of component as described above. The substrate 420 may be any type of substrate as described above. In the present example, the illustration is given for a die on a wafer. In advantageous embodiments, a substrate 420 comprising a plurality of components 410 positioned on that same substrate is obtained. The latter may allow applying at least part of the packaging method simultaneously to the plurality of components 410, thus resulting in a time efficient process. More particularly, a part of the encapsulation process then can be performed simultaneously for different components, resulting in a gain in time, cost and effort. In FIG. 3 the illustration is given for a substrate 420 comprising two components 410. Typically such components 410 may be spaced by a predetermined distance, which in the case of dies can be referred to as the scribe line.

[0043] In a second step 220 a component 410 on a first part of the substrate 420 is separated from the remainder part of the substrate 420 such that a sloped side wall is induced for the packaged device and in a third step 230 encapsulation of the separated component 410 on the first part of the substrate 420 is encapsulated. These steps may be performed using a plurality of sub-steps, the invention not being limited thereto and a number of these sub-steps being optional. These sub-steps will further be described in more detail.

[0044] In optional step 240, an optional protective coating 412 is applied to the surface of the substrate 420 whereon or wherein the component 410 is made. Application of a protective coating 412 may prevent the component 410 from becoming damaged during future steps in the processing. Such a protective coating 412 may for example be made from a passivating material, such as for example an oxide or nitride like TiN, TaN, TiO₂, a carbide such as SiC, a metal such as Ti, Ta. Also a multilayer could be used combining properties of different of these layers. The latter may result in an improved reliability. Whereas polymers typically may have a low density and therefore may act as a poorly reliable diffusion barrier or protection barrier, it could be used in combination with other layers.

[0045] In step 250, dicing of a recess 414 is performed in the surface of the substrate 420. The position of the recess 414 typically may correspond with a position of an edge of a packaged device. Therefore the position for forming the recess may be selected close to the position of the component, so that the volume of the packaged device can be kept small, or in between different components 410, if different components 410 are present on the same substrate 420. The dicing of the recess 414 in the present example is performed using a blade shaped so that a recess 414 with at least one sloped wall 416 (oriented non-perpendicular to the top substrate surface) is made. The blade shape therefore typically may have

significantly sloped blade sides. The angle made by the blade sides may be for example between 45° and 60°, the present invention not being limited thereto. Instead of dicing, also other physical techniques could be used for obtaining a recess with at least one sloped wall, so as for example laser cutting using a particular laser profile. The recess made in this and following step 260 advantageously does not extend through the whole substrate 420, so that the substrate 420 still is a single piece. In other words, for the present example, dicing is performed only partially so that recesses 414 are formed that do not run through the whole substrate 420 and so that the components are not fully separated from each other. The latter will assist in simultaneously applying a part of the encapsulation step for a plurality of components, if present on the substrate. Depending on the type of blade chosen (e.g. a symmetrical blade or not), one or two sloped walls 416 will be created for the recess 414. Applying a physical technique so that sloped surfaces 416 are obtained will allow creation of rounded corners or less sharp corners, which is advantageous for use in bio-medical applications. The result of this dicing step is shown by the recess 414 in FIG. 3 part (a)

[0046] In step 260, further creation of the recess is performed by dicing at the same position as in step 250 but using a blade inducing a recess with straight walls 418. Again, alternatively, other physical techniques also could be used. The resulting combination of the two dicing processes can be seen as the recess 414 in FIG. 3 part (b). The result of step 250 and 260 is a recess, also referred to as a trench wherein the top is wider than the bottom. It is to be noticed that in particular embodiments, the order of steps 250 and 260 can be interchanged, so that first the recess with substantially straight walls is made and thereafter the sloped walls are introduced in the recess. Furthermore, in some embodiments, where reduction of the sharpness of edges is only required at one side, the recess may run through the complete substrate. In the latter case no further dicing or separation will be required. Some embodiments of the present invention thus may be characterized by the fact that a recess or cut is formed by using a double physical process creating differently sloped walls, e.g. a double dicing or cutting technique whereby walls with different slopes are induced.

[0047] In step 270, surface damage advantageously may be removed. The latter may for example be performed using surface plasma treatment, including dry etching, although the invention is not limited thereto. Another example of a technique that could be used is wet etching.

[0048] In an additional step 280, the optionally applied protective topcoat 412 for protecting the component, in the present example die, is removed. The latter may for example be performed using dry or wet etching. An example of a topcoat material that can be used is photoresist, although the invention is not limited thereto.

[0049] In step 290, a first capping layer 440 may be applied to the top surface and at the walls in the recess

414. Due to the shape of the recess 414, step coverage by the capping layer is good. Consequently, even using standard deposition techniques and relatively low temperatures, a good and relatively homogeneous capping layer can be formed, which may, after it also has been applied to the back (see further), allow for a first complete sealing. Selection of the appropriate materials for obtaining good biocompatibility may also be performed. The capping layer 440 also may be selected so that it acts as a diffusion barrier. Whereas for sealing the whole device, it is required to have an overall coverage, in some embodiments of the present invention sealing of the upper and side part of the device may be sufficient and no further first capping layer 440 may be applied. The applied first capping layer 440 is indicated in FIG. 3 part (b).

[0050] According to the present exemplary packaging method 200, the device is then fixed 300 on a carrier 424 using for example a layer of glue 426, as indicated in FIG. 3 part (c). In this way, the backside of the substrate becomes available for processing. In step 305, thinning of the backside of the substrate is performed. Such thinning may for example be performed until a thickness of 80µm, although the invention is not limited thereto. The thinning may be performed until the trenches, also referred to as recesses, are reached that are previously made at the front side of the substrate. In this way, different dies, if present on the substrate, are physically separated from each other. The previously formed recesses thus become cuts. The thinning may be performed using the conventional thinning processes.

[0051] In step 310, the edge may be provided with a sloped side wall. Advantageously, the latter may be performed simultaneously for different dies, using a technique rounding both edges of the cut simultaneously. The provision of sloped side walls will allow that also the corners at the edges on the backside of the substrate will be less sharp. The sloped side walls at the back may be made using a dicing technique with sloped blade, although the invention is not limited thereto. The sloped side walls may for example also be made using a physical technique for creating sloped side walls, or even a chemical etching technique for creating a sloped side wall, or other process. The result of the creation of the sloped side walls can be seen in FIG. 3 part (c).

[0052] Optionally remaining particles and/or the surface damage induced by the thinning process and by the technique used for creating sloped side walls may be removed, as shown in step 320, e.g. by surface plasma treatment. Such a step may have a cleaning effect, whereby all particles related to the wafer thinning and dicing are removed, and a smoothing effect, wherein any damage and roughness can be reduced or removed. Materials that could be used for this cleaning and/or smoothing step are for example HF, HNO₃, Acetic Acid, HCl, TMAH, KOH.

[0053] In case full encapsulation is envisaged, which may often be the case in bio-medical applications, the first capping layer 440 now optionally also may be applied

to the bottom surface and the side walls previously being part of the recess. Again, in case rounded corners are provided, this may assist in obtaining a good step coverage. Application of the first capping layer 440 to the bottom side is indicated by step 330. In FIG. 3 part (d) the presence of the capping layer 440 is indicated.

[0054] In optional step 340, the carrier is removed, now resulting in one or more individually packaged devices separated from each other. The latter can also be seen in FIG. 3 part (d).

[0055] In optional step 350, cleaning of the component may be performed. Materials that could be used for this cleaning step are for example, water, IPA, NPA, Acetone, DMSO, NMP a mixture of SC1 and SC2, etc.

[0056] Techniques for performing cleaning or smoothening such as for example provided for in steps 320 and 350 may comprise batch processing or single wafer processing, dispensing of chemical through a puddle, spraying, high pressure nano spraying, such spraying assisted with ultrasonics, megasonics, etc.

[0057] In a further optional step 360, an additional encapsulation may be applied, e.g. by embedding the device in a silicone layer. Examples of bio compatible materials that can be used are Parylene, Hydrogels, etc. Materials that could be used preferably have a good biocompatibility, are soft, are flexible and are reliable. The encapsulation may be made as multilayer of different materials. For example, embodiments of the present invention not being limited thereby, the multilayer may comprise one layer having anti-inflammatory properties, e.g. a layer including anti-inflammatory drugs, one layer having the property of being soft, ... Such an additional encapsulation may result in a two-layer encapsulation that provides an hermetic encapsulation making the packaged device suitable for bio-medical applications. The resulting packaged device is shown in FIG. 3 part (e). Further encapsulation by applying additional layers also may be performed

Whereas in the above exemplary method, the process is given for a particular shape of the blade, such shape may be adjusted. The selected shape of the blade and the corresponding recess made, may depend on the thickness of the substrate, the distance between neighbouring components, if these are present, etc.

[0058] In a second particular example, a similar processing sequence as in the first particular example may be adapted, but the step or steps of dicing with a dicing blade inducing a recess with sloped surfaces may be performed with a blade having a different shape. Depending on the blade shape, the initial shape of the recess may be different. Whereas in the first particular example the initial blade had two sloped sides and a broad flat surface as blade edge, FIG. 4 illustrates a similar process wherein the blade has two sloped sides touching each other substantially at a line edge and having no additional flat surface. From the shape of the recess 414 it can be seen that the shape of the blade used for the initial dicing is different from the blade used in the exam-

ple shown in FIG. 3. In FIG. 5A the effect of the two blade shapes is shown in more detail, FIG. 5A part (a) illustrating the situation for a blade having sloped blade sides 512, 514 reaching each other at an edge 516, and FIG. 5A part (b) illustrating the situation for a blade having an additional flat portion 518 at the cutting edge. The final shape of the recess, after combining the sloped surface dicing and straight dicing is the same. By way of illustration, scanning electron microscope images are shown in FIG. 5B of a recess created with a straight blade (part (a)), a recess created with a bevel blade (part (b)) and a recess created by combining a cut with a straight blade and a cut with a bevel blade (part (c)). In some embodiments according to the present invention, the recess advantageously is obtained by first providing the cut with the straight blade and thereafter providing the cut with the bevel blade.

[0059] In one particular embodiment, the packaging method furthermore is adapted for providing feedthroughs to pass signals, data or materials to and from the component. Such feedthroughs may for example include electrodes to transfer electrical signals, although the invention is not limited thereto. FIG. 6a and FIG. 6b illustrate examples of a feedthrough 550 for a packaged device according to an embodiment of the present invention, in the present examples being an electrode for transferring electrical signals. The electrode 550 may be provided after the provision of the encapsulation 440, 450, e.g. by locally removing the encapsulation 440, 450 so that the surface of the component 410 is free and by providing the electrode 550 on the surface of the component 410 in any suitable way, e.g. by depositing a metal layer. An example thereof is shown in FIG. 6a. Alternatively, the electrode 550 also may be provided before or in between different steps of the packaging process so that the feedthrough 550, in the present example being an electrode, can be partially covered by an encapsulant 450. FIG. 6b illustrates an example whereby the component 410 on the substrate 420 is first covered by a capping layer 440, then, after local removal of the capping layer 440, the electrode 550 is provided and thereafter the encapsulation layer 450 is provided partially covering the electrode. The latter may for example be advantageous if free end portions of the electrode would result in unwanted electrical, chemical or physical behavior. Depending on the behavior envisaged for the feedthroughs 550, the most appropriate method for providing the electrode may be selected. Other feedthroughs that may be provided may for example be liquid feedthroughs for capturing liquids in a component acting as a microfluidic device. If the device or die is for example a MEMS device with a sensor that needs to be in direct contact with bodily fluids, the feedthrough may be just a hole and the sensor part may be made biocompatible, taking care on hermetic closure in itself. Another possibility is a device being or comprising a MEMS with membrane for pressure sensing. This membrane can be encapsulated if necessary for biocompatibility or hermeticity but care should be tak-

en, since the encapsulation has to be done allowing reliable pressure sensing.

[0060] According to particular embodiments, the processing performed for packaging the device may be selected such that all processing is performed at temperatures below 400°C. Embodiments wherein rounded edges are induced in the device are especially suitable for low temperature processing as the step coverage when depositing a layer is inherently better.

[0061] In advantageous embodiments, the packaging/encapsulation processing is performed without leaving traces that are non-biotolerable. For example, the processing steps, more particularly those related to packaging/encapsulation may be selected such that no toxic solvents are used, no copper Cu is used or no nickel Ni is used. So, whereas Cu can and typically will be used in CMOS processes itself, it is avoided in the packaging/encapsulation processes. In order to check biocompatibility, after separation and encapsulation of the dies, testing may be performed on biocompatibility.

[0062] It is an advantage of embodiments according to the present invention that the method for packaging makes use of at least one physical process for the separating step. The packaging methods may be substantially independent on the materials used for the device, whereas for example when using etching different etch steps are required for different substrate materials. Application of a physical separation method is relatively fast resulting in an acceptable manufacturing time. Physical processes such as dicing are fast and cheap, resulting in an economically viable method. Furthermore, the physical processes used for separating are less complex compared to for example sloped etching.

[0063] In one embodiment according to the present invention, a method for packaging a chip is described whereby the method is characterized by the steps of obtaining a chip on a substrate and providing a hermetic bio-compatible packaging by providing a first capping layer and a further encapsulation layer in solid contact with the chip integrated on the substrate. Although advantageous for obtaining good step coverage and therefore for having an improved encapsulating reliability, the creation of sloped edges for the device during separation is not strictly required. Other features and advantageous for using stacked layer encapsulation can be seen in the embodiments described above.

[0064] In a second aspect, the present invention relates to a packaged device for bio-medical applications. The device may be an integrated circuit, MEMS or other device, as also indicated in the description of the first aspect. In one embodiment, the present invention relates to a device for biomedical applications comprising a component provided on a substrate and at least one sloped side wall induced using a physical process. Such sloped side wall of the device may enhance step coverage of a capping layer applied for encapsulation, avoid injury or damage, etc. In another embodiment, the present invention relates to a device for bio-medical applications com-

prising a component provided on a substrate and having a hermetic bio-compatible packaging comprising a capping layer, being a first encapsulation and typically being a biocompatible layer also acting as diffusion barrier, and an encapsulation layer, being a second encapsulation. Such encapsulation, which typically may be provided in solid contact with the component and/or substrate e.g. be deposited on the component and the substrate, may ensure good biocompatibility of the packaged device during and after implantation. In still a further embodiment, the present invention relates to a packaged device for use in bio-medical application, the packaged device being biocompatible and the packaged device comprising a combination of features of the first particular embodiment of the second aspect and features of the second particular embodiment of the first aspect. By way of illustration, the present invention not being limited thereto, an example of a biocompatible device is shown in FIG. 7, illustrating standard and optional features of the packaged biocompatible device. The biocompatible device comprises a component 410 and a substrate 420, which may be similar to those parts as described above and in the first aspect. The device furthermore comprises at least one sloped side wall 430, which also may be referred to as a rounded edge. Advantageously, such sloped side walls 430 or rounded edges may be present at a plurality of edges or even at each edge of the packaged device 400. The sloped side walls 430 or rounded edges 430 may be made using a method as described in the first aspect of the present invention, although the invention is not limited thereto. Such sloped side walls 430 or rounded edges may enhance step coverage for a capping layer 440 that may be present. It may assist in avoiding damage of an encapsulation material 450 that may be present or assist in avoiding injury of tissue after implantation. As indicated the component and substrate may be encapsulated with a first encapsulation being a biocompatible capping layer 440 or biocompatible capping layers 440. These advantageously may have the function of a diffusion barrier, preventing diffusion from elements from the device into the body where the device is implanted and/or preventing diffusion from elements from the body into the device, which may result in malfunctioning. Layers that can be used as capping layers may be selected based on their biocompatibility. As indicated above the rounded corners may assist in obtaining a good coverage. It is to be noticed for some applications that the capping layer does not need to be present at all sides of the device, whereas for other applications e.g. for some bio-medical applications full hermetic encapsulation is required and obtained with the stacked layer encapsulation. The materials that may be used as capping materials may be silicon oxide, silicon nitride, bio compatible polymers, etc. Advantageously multilayers can be used combining properties of several layers.. As indicated advantageously also a second encapsulation material 450 may be present. Such an encapsulation material 450 may be an embedding in for example sili-

cone, Examples of bio compatible materials that can be used are Parylene, Hydrogels, etc. Materials that could be used preferably have a good biocompatibility, are soft, are flexible and are reliable. The encapsulation may be made as multilayer of different materials, as also described above. As discussed above for the packaging method, additional feedthroughs for passing data or materials also may be provided. In case feedthroughs for passing electrical signals are provided, such feedthroughs may be electrodes made of biocompatible conductive materials such as for example inert metals, Ti, Ta, Pt, Au, IrO₂, PEDOT.

[0065] In a third aspect, the present invention relates to an implantable system, the implantable system comprising at least one implantable device according to an embodiment of the second aspect. The at least one implantable device may be a combination of different hetero- genous dies, advantageously packaged using a method as described above. Examples of such combinations may be CMOS logics (such as steering, programmable devices, ...), MEMS (such as membranes for example for pressure sensing, drug reservoirs, microfluidics for drug delivery, ...), battery, antenna (for example for loading a rechargeable battery, for programming a reprogrammable steering, ...). Any combination or subset of the mentioned dies can be used. Part of the dies or all dies can be encapsulated in one package. Different dies may be electrically connected via inter-die-metallization, whereby the inter-die-metallization can be included in the package. In case a flexible package is used, the inter-die-metallization is preferably stretchable. This can for example be obtained by shaping the metallization as a sine wave or horse shoe. Typical materials that can be used for the inter-die-metallization is gold or platinum, although the invention is not limited thereto and all, preferably biocompatible, conducting materials may be used. The overall system furthermore comprises a global packaging, encapsulating the different components of the system. Such global packaging or encapsulation may be applied using a wafer-level technique e.g. as described above, or may be applied using another technique, such as e.g. via injection moulding. By way of illustration, the present invention not being limited thereto, some examples of implantable systems are illustrated in FIG. 8 to FIG. 10. FIG. 8 illustrates a cross-sectional view (A) and a top view (B) of an implantable system 800 comprising two packaged dies 810, 820 according to embodiments of the second aspect electrically interconnected via an inter-die-metallization 830, in the present example being a set of two metal connections. The dies and the metallization are supported using a flexible or stretchable support 840 to which the packaged dies 810, 820 are bonded via a bonding 850. A global encapsulation, 860 encapsulates the different components to safeguard the biocompatibility of the system 800. The system 800 can be provided with a global feedthrough 870, which may be an electrical feedthrough, fluid feedthrough, etc. comparable to the feedthroughs as described above for the

packaged devices. FIG. 9 illustrates an example of a similar structure, whereby the support 840 is only provided for supporting the dies 810, 820 and not the metallization. In FIG. 10 a configuration without support 840 is shown. It will be appreciated by the person skilled in the art that the systems as shown in FIG. 8 to FIG. 10 are only examples of a plurality of different configurations of implantable systems encompassed within the scope of embodiments of the present invention.

[0066] Whereas in the examples of FIG. 8 to FIG. 10 a global biocompatible encapsulation is provided wherein only electronics and metallization is embedded, optionally also further encapsulation may be applied. For example, in case the total system is not only composed of dies, e.g. silicon based chips, and interconnects, but also contains other subparts such as for example a battery or passives, a further embedding can be applied, as shown in FIG. 11. In the present example, applying a further global embedding 910 can be carried out with or without the use of a flexible substrate, depending on the particular implantable device. The further embedding 910 can provide additional support for a multitude of sub-devices. Via a feed through 920 an intermetallization 930 to connect the electronic subparts with the other parts 940 can be performed. The interconnect pitch may typically be larger. Consequently, board level embedding techniques can be selected for the fabrication step, whereas for a first global encapsulation both board level and wafer level embedding technologies may be considered, since smaller metallization pitches will be envisaged for the first global encapsulation. It is to be noticed that such an additional global embedding can be performed outside a clean room. In some embodiments, thus global embedding may first be done at the level of some electronics components and metallization with a first embedding layer, in an interposer-like package, and further embedding may be performed for further enclosing other components such as for example a battery.

[0067] It is an advantage of embodiments according to the present invention that packaging can be performed in two phases, a first whereby encapsulation is performed for generating a diffusion barrier and for creation of feedthroughs and a second phase, wherein global interconnecting and embedding is performed. The last phase can provide mechanical support of the system, electrical interconnections between dies, creation of functional feedthroughs, etc.

[0068] By way of illustration, embodiments of the present invention not being limited thereby, an example of a step coverage that can be obtained for an encapsulated device encapsulated via a method as described above is shown in FIG. 12 and discussed below. The embedding uses a passivation stack of 50nm SiC, 400nm oxide and 500nm Si-nitride. A further top encapsulation layer of silicon oxide was selected. The oxide encapsulation at the top had a total thickness of 1.5µm. One technique applied in the present example to further strengthen the hermeticity after encapsulation is the provision of

the encapsulation by depositing the encapsulation layer in a two-step process. Instead of depositing a single layer with thickness of $1.5\mu\text{m}$, the encapsulation layer is built up from 2 oxide layers, in the present example each being about $0.8\mu\text{m}$ thick and deposited immediately after each other. By fabricating the oxide encapsulation as a two-layer stack, the influence of an occasional pinhole on later diffusion is reduced, as it is unlikely that pinholes in two different layers will occur at the same location. This principle can be applied to all embodiments of the present invention and is not limited to the present example. The device was also encapsulated at a bottom side, whereby the bottom encapsulation existed from a stack of two oxide layers having a total thickness of $1.5\mu\text{m}$ and whereby no passivation stack was present. The latter typically may be left out since the bottom side of the dies contain no patterns of Cu or other harmful materials. As is understood, the external chip electrodes typically are fabricated in a biocompatible material since these are not covered by a diffusion barrier.

[0069] By way of illustration, the functionality of the encapsulation technique as diffusion barrier is tested. One test illustrating the diffusion barrier properties relates to encapsulation of silicon dies prepared with Cu patterns on the topside, using a conventional damascene process. The dies are rounded using a method according to the present invention. The top encapsulation used was as described in the exemplary structure above. In order to test the encapsulation and biocompatibility, cell culture tests were carried out, using neonatal rat cardiomyocytes as test cells. In a well plate, culture medium and cells were brought into contact with 3 types of chips : an encapsulated chip as described above whereby Cu patterns are covered with a passivation layer stack and an encapsulation layer, referred to as tests A, chips whereby only a passivation layer on top of the Cu is present, referred to as tests B, and chips without covering layer, i.e. whereby the Cu patterns are uncovered, referred to as tests C. The wells had 1, 2 or 4 dies of each type of chips, all chips being $5\times 5\text{mm}^2$. After a co-culture of 5 days, a live-dead cell assay was applied and the fluorescent intensity of each well was measured, as shown in FIG. 13. Since only cells which are alive are fluorescent, the determined intensity was a figure of merit for the amount of living cells. Taking into account that Cu is poisonous, it can be seen that passivation already blocks the Cu diffusion already quite well, while the gain is even larger when also an oxide encapsulation was applied. The latter illustrates that good biocompatible packaged devices can be obtained.

Claims

1. A method for biocompatible packaging an implantable device, the method comprising
 - obtaining a component (410) on a substrate

(420)

- separating the component (410) and a first part of the substrate (420) from a second part of the substrate (420), and

characterized in that separating comprises:

- using a physical technique for obtaining a recess with at least one sloped side wall,
- using a physical technique at the same position as in the previous step, for further creation of the recess, inducing straight walls in the recess, thus resulting in a recess in the top surface of the substrate having a top being wider than a bottom
- providing an encapsulation for the component (410).

2. A method for biocompatible packaging according to claim 1, wherein using the at least one physical process comprises at least dicing using a blade with sloped blade surfaces, having an angle between the blade sides ranging between 45° and 60° , so as to create a recess (414) or cut with sloped side walls.
3. A method according to any of the previous claims, wherein separating comprises using a physical process inducing a sloped surface in the first part of the substrate (420) at the side of the substrate (420) where the component (410) is present on the substrate (420).
4. A method for biocompatible packaging according to any of claims 1 to 3, wherein separating and providing an encapsulation comprises
 - depositing a first capping layer (440) covering a top surface of the substrate (420) and at least part of the recess (414).
5. A method for biocompatible packaging according to any of claims 1 to 4, wherein said providing a recess (414) in a top surface of the substrate (420) comprises
 - applying a first dicing process to the top surface with a blade providing a cut with side walls perpendicular to the substrate top surface, and
 - applying at least one second dicing process to the top surface with a blade providing a cut with sloped side walls non-perpendicular to a surface of the substrate (420), whereby the angle of a sloped side wall and the perpendicular on the top surface ranges between $45^\circ/2$ and $60^\circ/2$, the first dicing process and the second dicing process being performed at substantially the same location on the substrate surface.

6. A method for biocompatible packaging according to any of the previous claims, wherein separating comprises using a second physical process inducing a sloped surface in the first part of the substrate (420) at the side of the substrate (420) opposite to the side of the substrate (420) where the component is present on the substrate (420).
7. A method for biocompatible packaging according to any of the previous claims, wherein separating and providing an encapsulation furthermore comprises
- thinning the bottom surface of the substrate (420), at a position opposite to the recess (414) at the top surface of the substrate (420), so that a cut is formed and the first part of the substrate (420) is separated from the second part of the substrate (420), and
 - depositing a first capping layer (440) covering the bottom surface and at least part of the area corresponding with the walls of the cut at the bottom surface of the substrate (420).
8. A method according to claim 7, wherein after thinning the bottom surface of the substrate (420) the method comprises using a second physical process inducing at least one sloped side wall so that the edge at the bottom surface comprises a sloped side wall.
9. A method according to claim 8, wherein for thinning the bottom surface of the substrate (420), the substrate (420) is fixed with the top surface to a carrier before thinning and wherein the carrier is removed after inducing at least one sloped side wall at the bottom surface.
10. A method according to any of the previous claims, wherein the method furthermore comprises providing a further encapsulation layer (450) after said separating.
11. A method according to claim 10, whereby prior to providing a further encapsulation layer (450), an additional cleaning step is performed.
12. A method for biocompatible packaging according to any of the previous claims, the method comprising applying a protective top coating (412) for protecting the chip before using the at least one physical process inducing a sloped surface.
13. A method for biocompatible packaging according to any of the previous claims, the method comprising applying a plasma treatment for removing surface damage after using the at least one physical process inducing a sloped surface.
14. A method for biocompatible packaging according to

any of the previous claims, wherein providing an encapsulation for a component (410) comprises depositing an encapsulation layer using two subsequent and distinct depositions of sub-layers, the sub-layers forming the encapsulation layer.

Patentansprüche

1. Verfahren für das biokompatible Verpacken einer implantierbaren Vorrichtung, wobei das Verfahren Folgendes umfasst
- Erhalten eines Bauelements (410) auf einem Substrat (420)
 - Trennen des Bauelements (410) und eines ersten Teils des Substrats (420) von einem zweiten Teil des Substrats (420), und
- dadurch gekennzeichnet, dass** das Trennen Folgendes umfasst:
- Verwenden einer physischen Technik zum Erhalten einer Vertiefung mit mindestens einer abgeschrägten Seitenwand,
 - Verwenden einer physischen Technik an derselben Position wie bei dem vorhergehenden Schritt, zum weiteren Schaffen einer Vertiefung, indem gerade Wände in der Vertiefung induziert werden,
- was in einer Vertiefung in der oberen Oberfläche des Substrats, die eine Oberseite hat, die breiter ist als ein Boden, resultiert
- Bereitstellen einer Kapselung für das Bauelement (410).
2. Verfahren für das biokompatible Verpacken nach Anspruch 1, wobei das Verwenden des mindestens einen physischen Prozesses mindestens das Verwenden einer Klinge mit abgeschrägten Klingenseitenflächen, die einen Winkel zwischen den Klingenseiten haben, der sich zwischen 45 ° und 60 ° erstreckt, umfasst, um eine Vertiefung (414) oder einen Schnitt mit abgeschrägten Seitenwänden zu schaffen.
3. Verfahren nach einem der vorhergehenden Ansprüche, wobei das Trennen das Verwenden eines physischen Prozesses umfasst, der eine abgeschrägte Oberfläche in dem ersten Teil des Substrats (420) an der Seite des Substrats (420), an der das Bauelement (410) auf dem Substrat (420) vorliegt, induziert.
4. Verfahren für das biokompatible Verpacken nach einem der Ansprüche 1 bis 3, wobei das Trennen und Bereitstellen einer Kapselung Folgendes umfasst
- Abscheiden einer ersten Deckschicht (440), die eine obere Oberfläche des Substrats (420)

- und mindestens einen Teil der Vertiefung (414) bedeckt.
5. Verfahren für das biokompatible Verpacken nach einem der Ansprüche 1 bis 4, wobei das Bereitstellen einer Vertiefung (414) in einer oberen Oberfläche des Substrats (420) Folgendes umfasst
- Anwenden eines ersten Vereinzelnungsprozesses auf der oberen Oberfläche mit einer Klinge, die einen Schnitt mit Seitenwänden senkrecht zu der oberen Oberfläche des Substrats bereitstellt, und
 - Anwenden mindestens eines zweiten Vereinzelnungsprozesses auf der oberen Oberfläche mit einer Klinge, die einen Schnitt mit abgechrägten Seitenwänden, die zu einer Oberfläche des Substrats (420) nicht senkrecht sind, bereitstellt, wobei der Winkel einer abgechrägten Seitenwand und der Senkrechten auf der oberen Oberfläche zwischen $45^\circ/2$ und $60^\circ/2$ liegt, wobei der erste Vereinzelnungsprozess und der zweite Vereinzelnungsprozess an im Wesentlichen derselben Stelle auf der Substratoberfläche ausgeführt werden.
6. Verfahren für das biokompatible Verpacken nach einem der vorhergehenden Ansprüche, wobei das Trennen das Verwenden eines zweiten physischen Prozesses umfasst, der eine abgechrägte Oberfläche in dem ersten Teil des Substrats (420) an der Seite des Substrats (420) gegenüber der Seite des Substrats (420), wo das Bauelement auf dem Substrat (420) vorliegt, induziert.
7. Verfahren für das biokompatible Verpacken nach einem der vorhergehenden Ansprüche, wobei das Trennen und Bereitstellen einer Kapselung ferner Folgendes umfasst
- Verdünnen der Bodenoberfläche des Substrats (420) an einer Position gegenüber der Vertiefung (414) an der oberen Oberfläche des Substrats (420), so dass ein Schnitt gebildet und der erste Teil des Substrats (420) von dem zweiten Teil des Substrats (420) getrennt wird, und
 - Abscheiden einer ersten Deckschicht (440), die die Bodenoberfläche und mindestens einen Teil der Fläche, die den Wänden des Schnitts an der Bodenoberfläche des Substrats (420) entspricht, bedeckt.
8. Verfahren nach Anspruch 7, wobei das Verfahren nach dem Verdünnen der Bodenoberfläche des Substrats (420) das Verwenden eines zweiten physischen Prozesses umfasst, der mindestens eine abgechrägte Seitenwand induziert, so dass die Kante an der Bodenoberfläche eine abgechrägte
- Seitenwand umfasst.
9. Verfahren nach Anspruch 8, wobei das Substrat (420) für das Verdünnen der Bodenoberfläche des Substrats (420) mit der oberen Oberfläche an einem Träger vor dem Verdünnen befestigt wird, und wobei der Träger nach dem Induzieren mindestens einer abgechrägten Seitenwand an der Bodenoberfläche entfernt wird.
10. Verfahren nach einem der vorhergehenden Ansprüche, wobei das Verfahren ferner das Bereitstellen einer weiteren Kapselungsschicht (450) nach dem Trennen umfasst.
11. Verfahren nach Anspruch 10, wobei vor dem Bereitstellen einer weiteren Kapselungsschicht (450) ein zusätzlicher Reinigungsschritt ausgeführt wird.
12. Verfahren für das biokompatible Verpacken nach einem der vorhergehenden Ansprüche, wobei das Verfahren das Aufbringen einer oberen Schutzbeschichtung (112) zum Schützen des Chips vor dem Verwenden des mindestens einen physischen Prozesses, der eine abgechrägte Oberfläche induziert, umfasst.
13. Verfahren für das biokompatible Verpacken nach einem der vorhergehenden Ansprüche, wobei das Verfahren das Anwenden einer Plasmabehandlung zum Entfernen von Oberflächenbeschädigungen nach dem Verwenden des mindestens einen physischen Prozesses, der eine abgechrägte Oberfläche induziert, umfasst.
14. Verfahren für das biokompatible Verpacken nach einem der vorhergehenden Ansprüche, wobei das Bereitstellen einer Kapselung für ein Bauelement (410) das Aufbringen einer Verkapselungsschicht unter Verwenden von zwei aufeinanderfolgenden und getrennten Abscheidungen von Subschichten umfasst, wobei die Subschichten die Kapselungsschicht bilden.
- Revendications**
1. Procédé d'emballage biocompatible d'un dispositif implantable, le procédé comprenant
- l'obtention d'un composant (410) sur un substrat (420)
 - la séparation du composant (410) et d'une première partie du substrat (420) d'une seconde partie du substrat (420), et
- caractérisé en ce que** la séparation comprend :

- l'utilisation d'une technique physique pour obtenir un évidement avec au moins une paroi de côté inclinée,
 - l'utilisation d'une technique physique à la même position que dans l'étape précédente, pour la création en outre de l'évidement, entraînant des parois droites dans l'évidement, aboutissant ainsi à un évidement dans la surface de dessus du substrat avec un dessus plus large qu'un dessous
 - la fourniture d'une encapsulation pour le composant (410).
2. Procédé d'emballage biocompatible selon la revendication 1, dans lequel l'utilisation de l'au moins un processus physique comprend au moins le découpage en dés à l'aide d'une lame avec des surfaces de lame inclinées, ayant un angle entre les côtés de lame allant de 45 ° à 60 °, de façon à créer un évidement (414) ou une découpe avec des parois de côté inclinées.
3. Procédé selon l'une quelconque des revendications précédentes, dans lequel la séparation comprend l'utilisation d'un processus physique entraînant une surface inclinée dans la première partie du substrat (420) du côté du substrat (420) où le composant (410) est présent sur le substrat (420).
4. Procédé d'emballage biocompatible selon l'une quelconque des revendications 1 à 3, dans lequel la séparation et la fourniture d'une encapsulation comprend
- le dépôt d'une première couche de recouvrement (440) couvrant une surface de dessus du substrat (420) et au moins une partie de l'évidement (414).
5. Procédé d'emballage biocompatible selon l'une quelconque des revendications 1 à 4, dans lequel ladite fourniture d'un évidement (414) dans une surface de dessus du substrat (420) comprend
- l'application d'un premier processus de découpage en dés à la surface de dessus avec une lame fournissant une découpe avec des parois de côté perpendiculaires à la surface de dessus du substrat, et
 - l'application d'au moins un second processus de découpage en dés à la surface de dessus avec une lame fournissant une découpe avec des parois de côté inclinées non perpendiculaires à une surface du substrat (420), moyennant quoi l'angle d'une paroi de côté inclinée et de la perpendiculaire sur la surface de dessus va de $45^\circ/2$ à $60^\circ/2$, le premier processus de découpage en dés et le second processus de découpage en dés étant réalisés sensiblement au même emplacement sur la surface de substrat.
6. Procédé d'emballage biocompatible selon l'une quelconque des revendications précédentes, dans lequel la séparation comprend l'utilisation d'un second processus physique entraînant une surface inclinée dans la première partie du substrat (420) du côté du substrat (420) opposé au côté du substrat (420) où le composant est présent sur le substrat (420).
7. Procédé d'emballage biocompatible selon l'une quelconque des revendications précédentes, dans lequel la séparation et la fourniture d'une encapsulation comprennent en outre
- l'amincissement de la surface de dessous du substrat (420), à une position opposée à l'évidement (414) au niveau de la surface de dessus du substrat (420), de sorte qu'une découpe soit formée et que la première partie du substrat (420) soit séparée de la seconde partie du substrat (420), et
 - le dépôt d'une première couche de recouvrement (440) couvrant la surface de dessous et au moins une partie de la zone correspondant aux parois de la découpe au niveau de la surface de dessous du substrat (420).
8. Procédé selon la revendication 7, dans lequel après l'amincissement de la surface de dessous du substrat (420), le procédé comprend l'utilisation d'un second processus physique entraînant au moins une paroi de côté inclinée de sorte que le bord au niveau de la surface de dessous comprenne une paroi de côté inclinée.
9. Procédé selon la revendication 8, dans lequel, pour l'amincissement de la surface de dessous du substrat (420), le substrat (420) est fixé avec la surface de dessus à un support avant l'amincissement et dans lequel le support est enlevé après entraînement d'au moins une paroi de côté inclinée au niveau de la surface de dessous.
10. Procédé selon l'une quelconque des revendications précédentes, dans lequel le procédé comprend en outre la fourniture d'une couche d'encapsulation supplémentaire (450) après ladite séparation.
11. Procédé selon la revendication 10, dans lequel, avant la fourniture d'une couche d'encapsulation supplémentaire (450), une étape de nettoyage additionnelle est réalisée.
12. Procédé d'emballage biocompatible selon l'une quelconque des revendications précédentes, le pro-

cedé comprenant l'application d'un revêtement de dessus protecteur (412) pour protéger la puce avant l'utilisation de l'au moins un processus physique entraînant une surface inclinée.

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- 13.** Procédé d'emballage biocompatible selon l'une quelconque des revendications précédentes, le procédé comprenant l'application d'un traitement au plasma pour éliminer un endommagement de surface après l'utilisation de l'au moins un processus physique entraînant une surface inclinée.

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- 14.** Procédé d'emballage biocompatible selon l'une quelconque des revendications précédentes, dans lequel la fourniture d'une encapsulation pour un composant (410) comprend le dépôt d'une couche d'encapsulation à l'aide de deux dépôts ultérieurs et distincts de sous-couches, les sous-couches formant la couche d'encapsulation.

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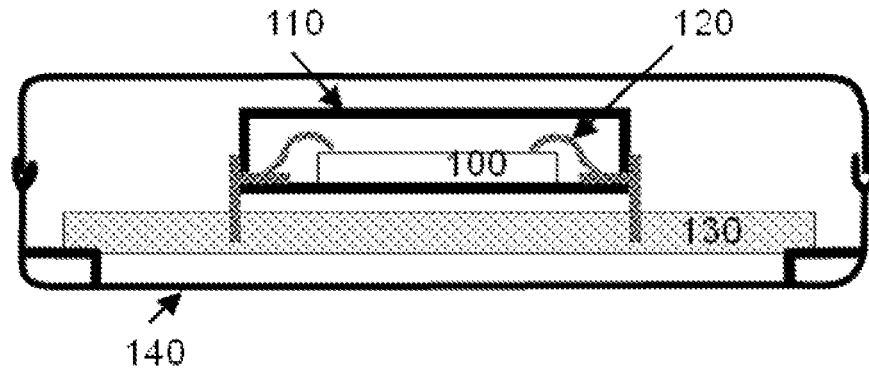


FIG. 1a

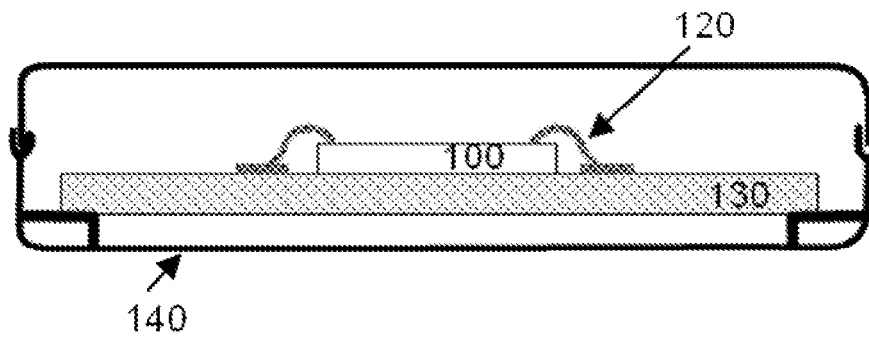


FIG. 1b

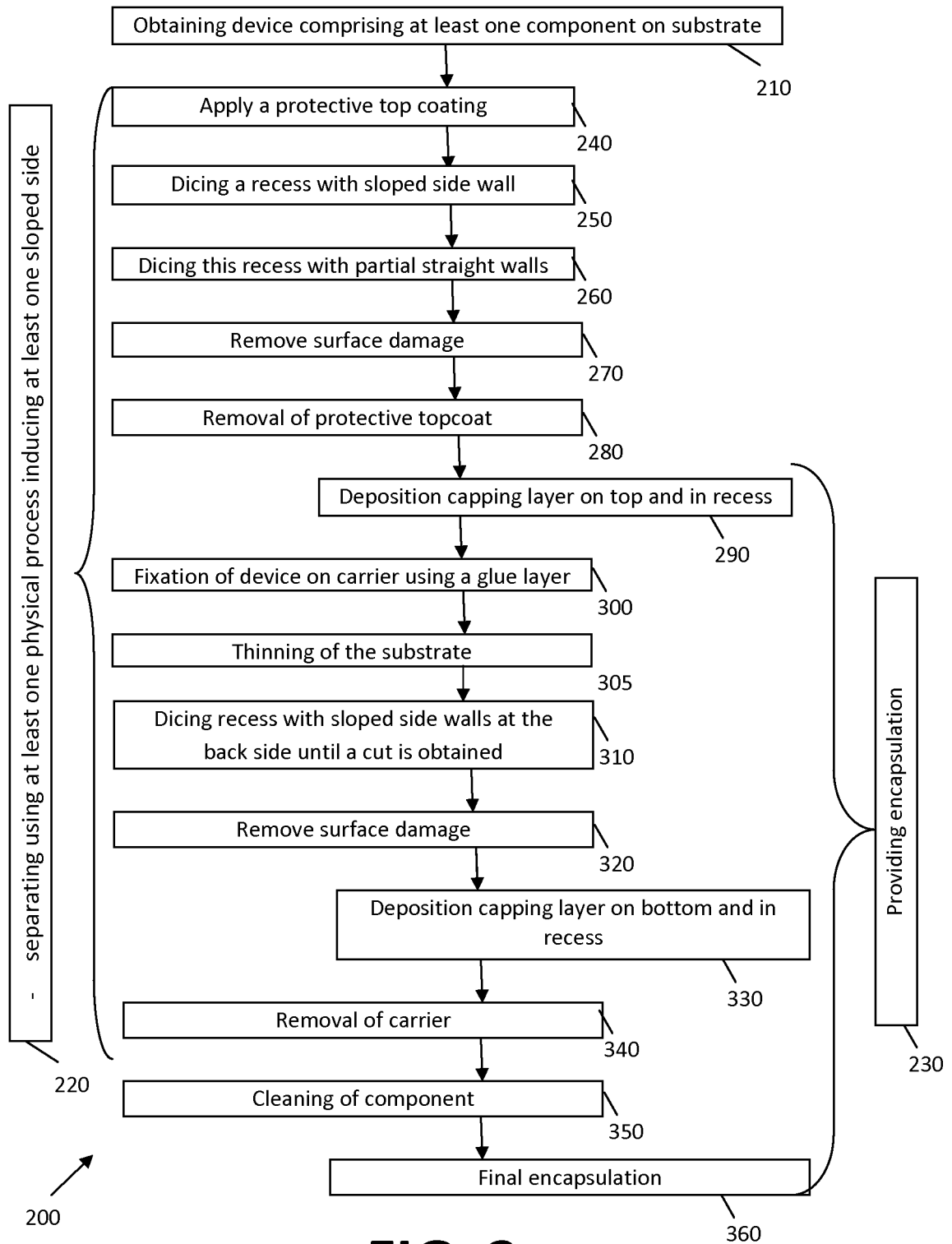


FIG. 2

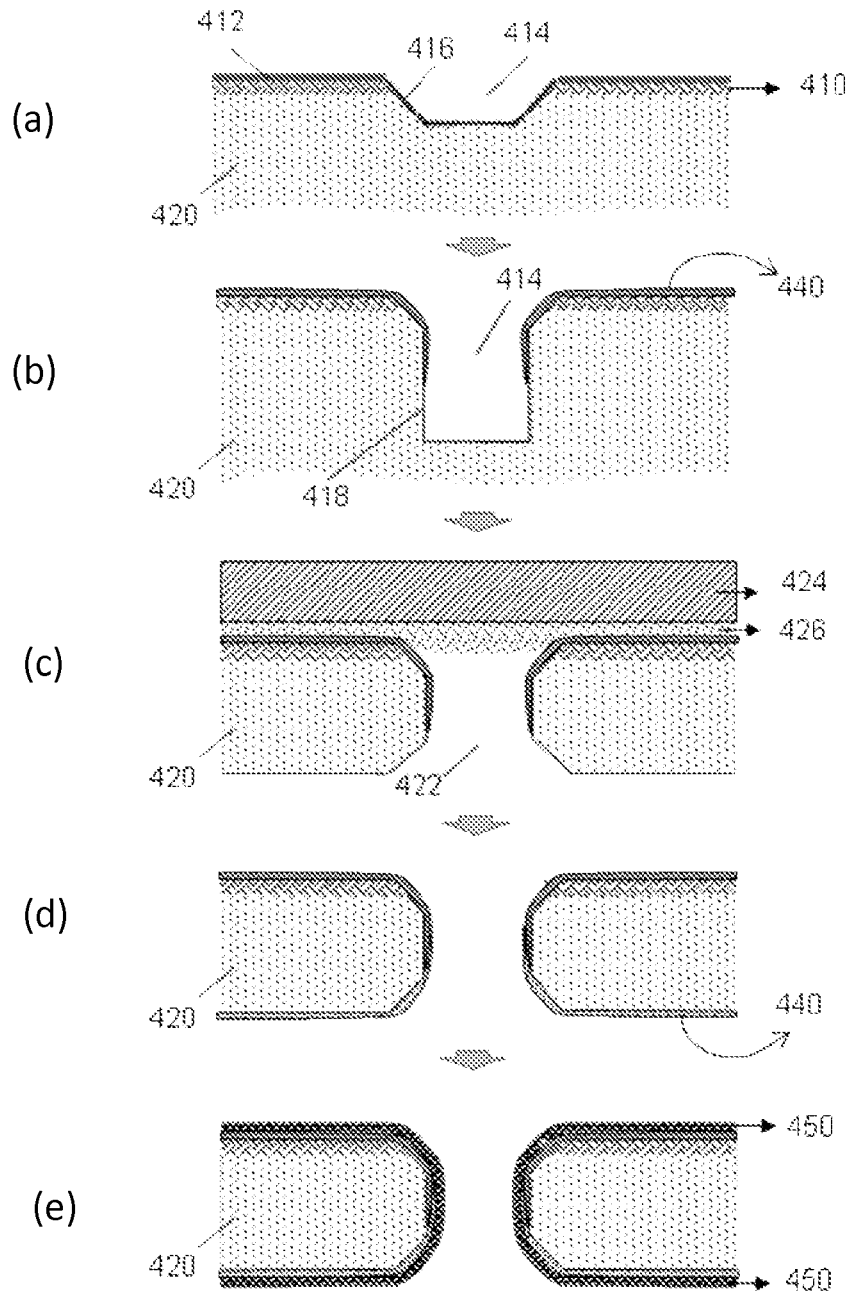


FIG. 3

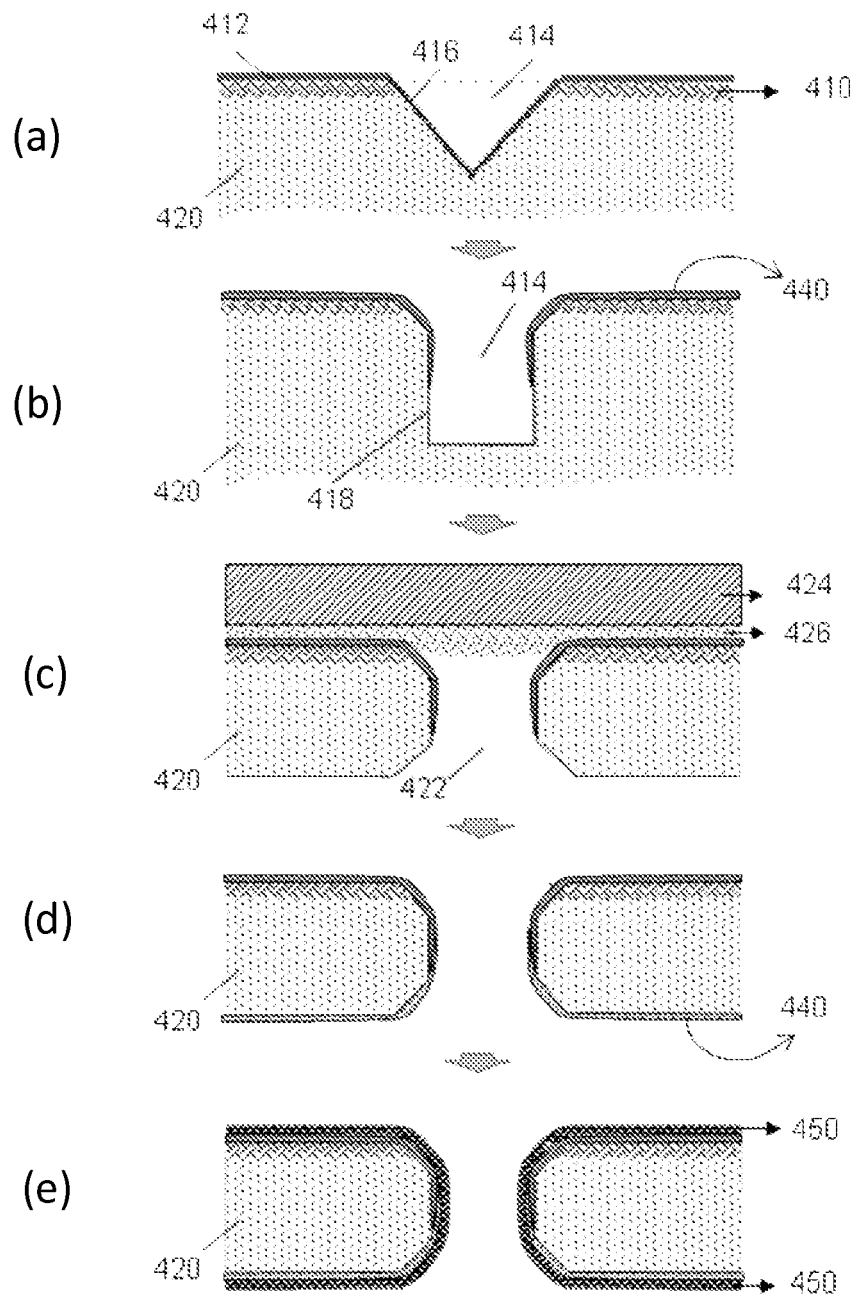


FIG. 4

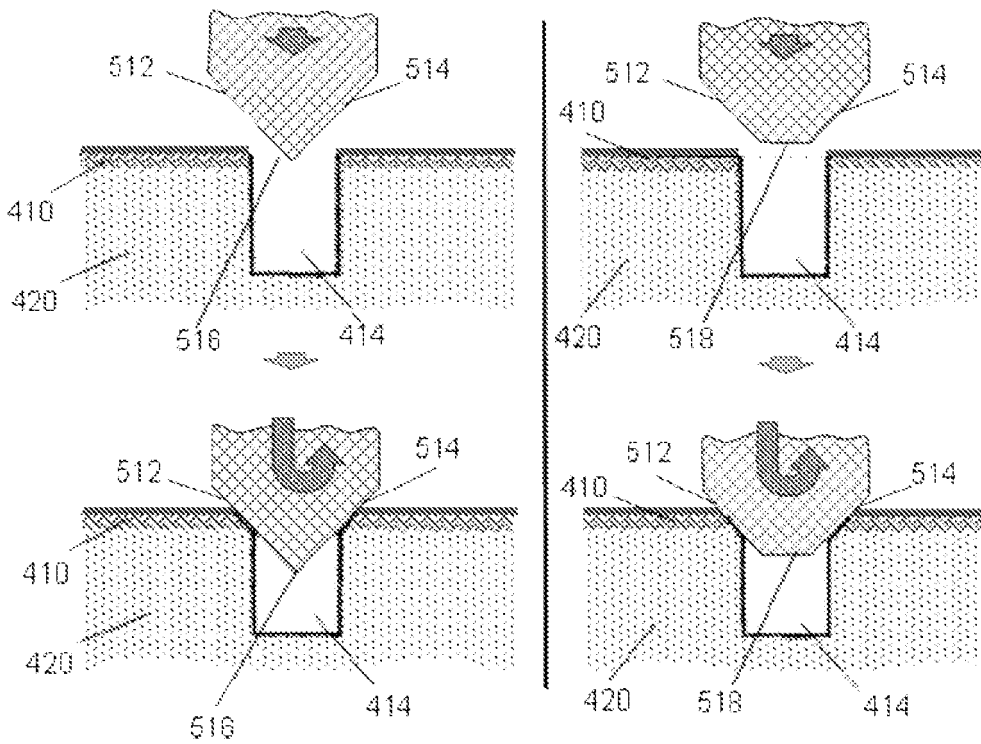
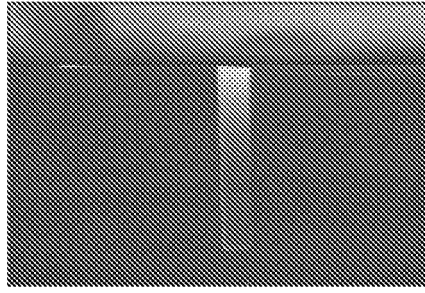
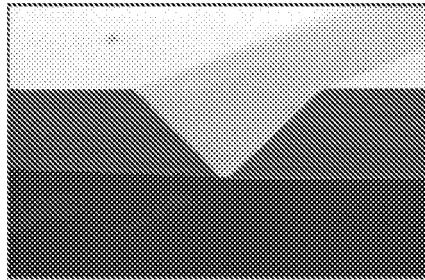


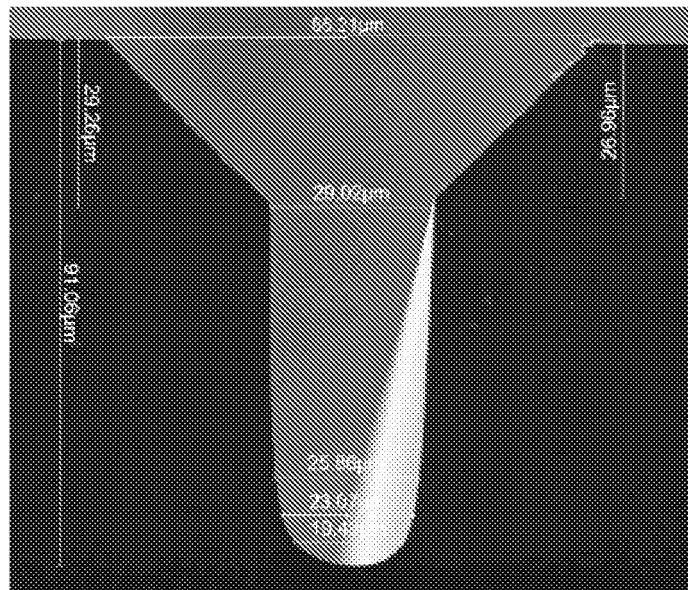
FIG. 5A



(a)



(b)



(c)

FIG. 5B

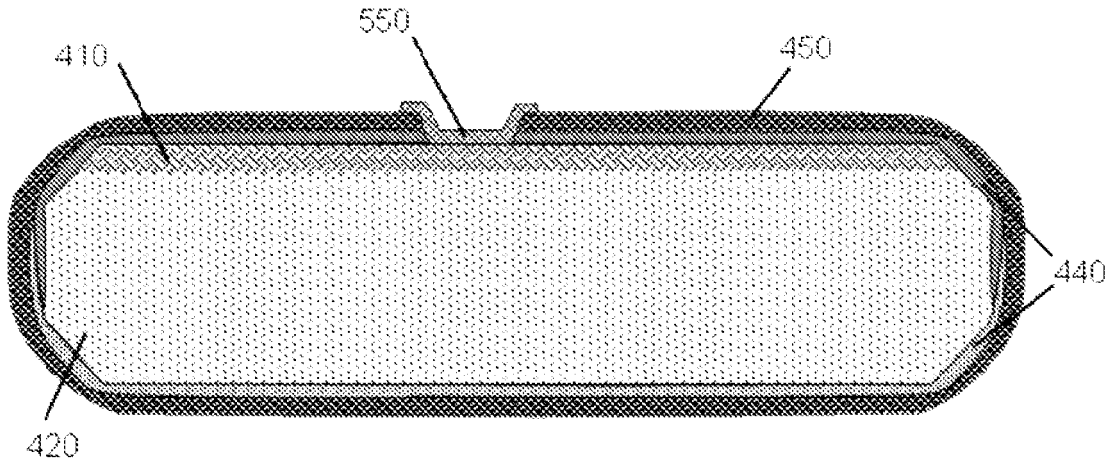


FIG. 6a

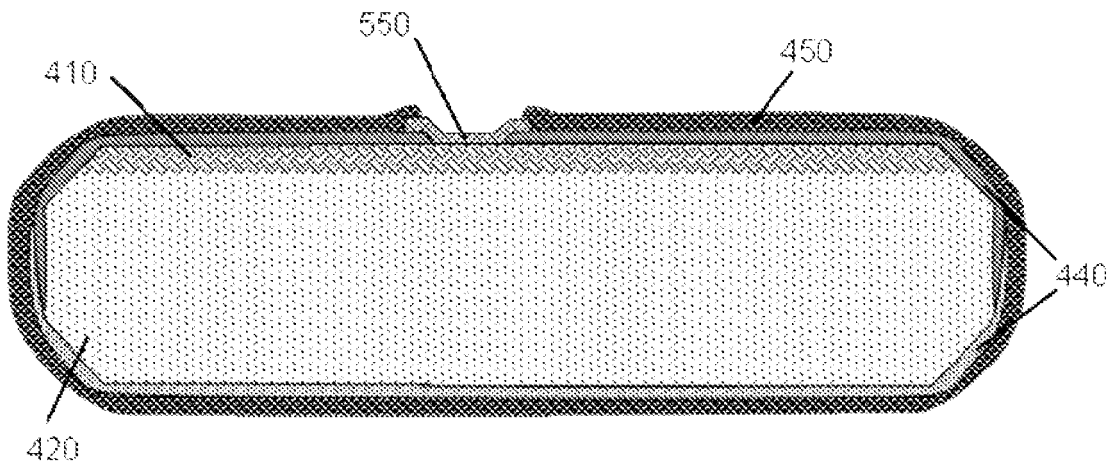


FIG. 6b

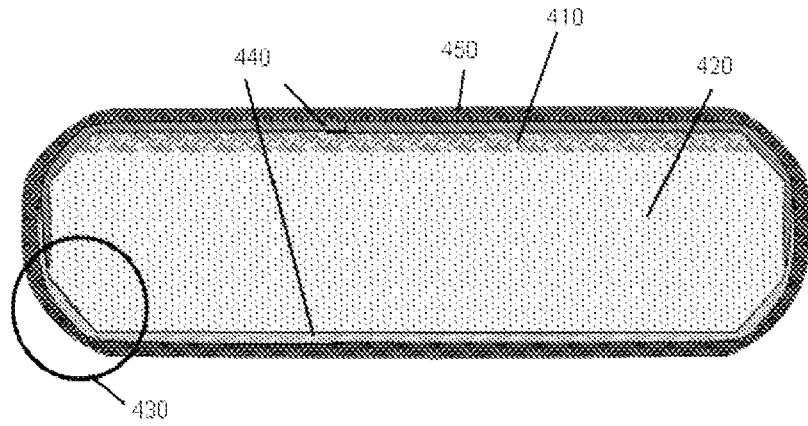


FIG. 7

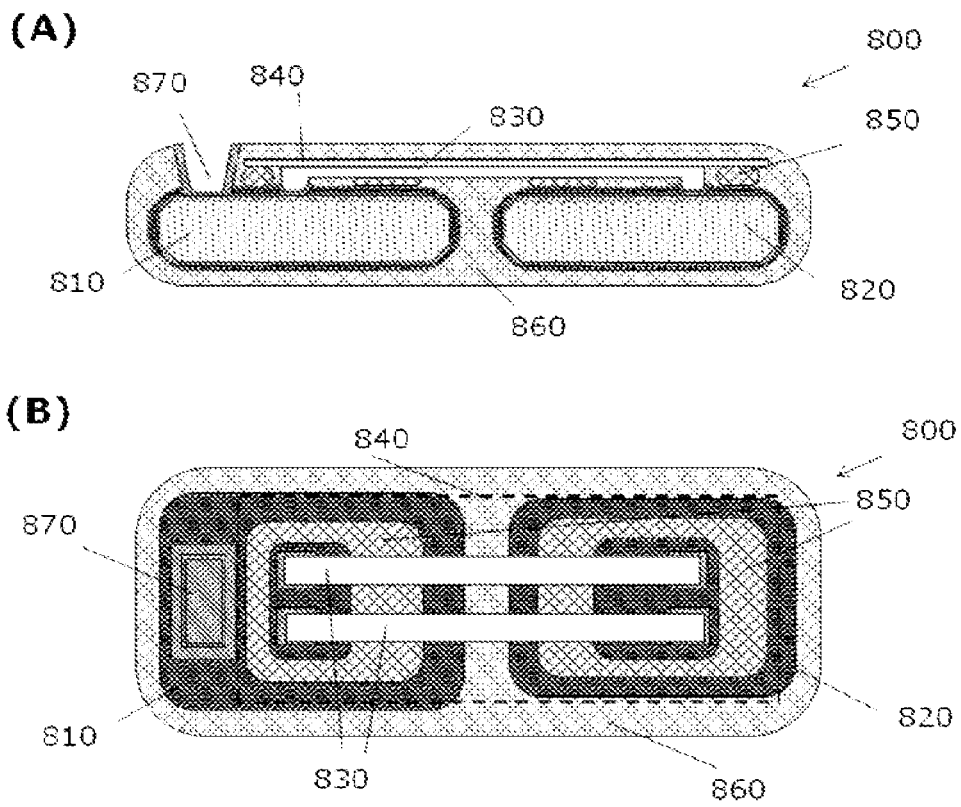


FIG. 8

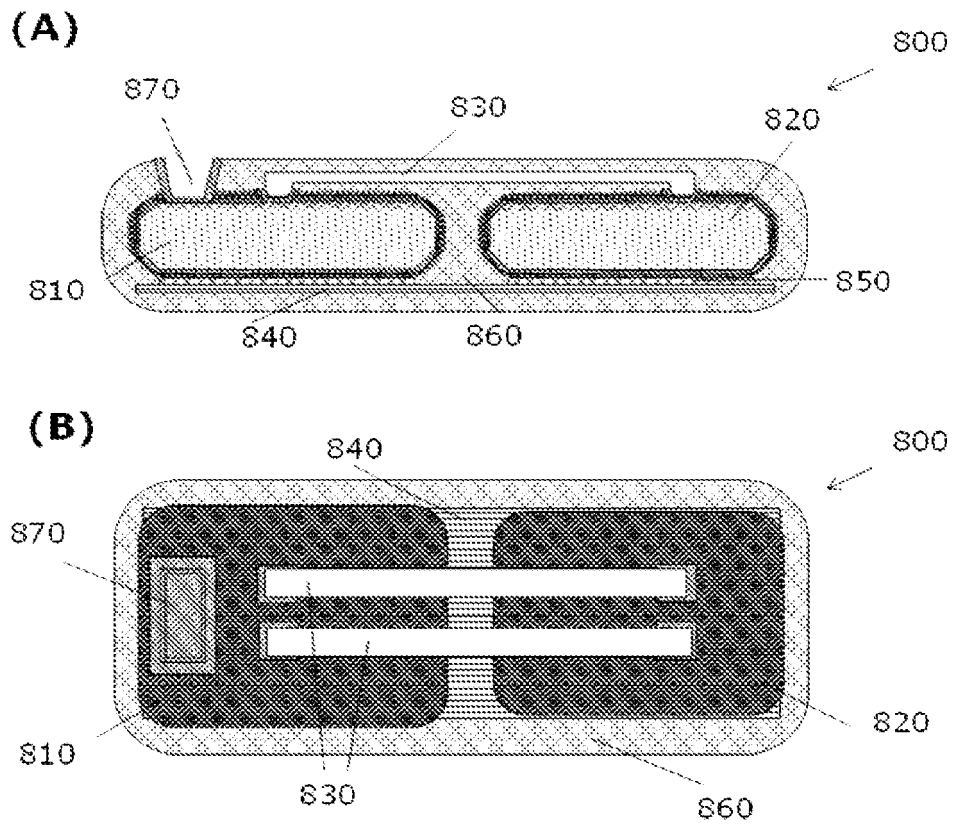


FIG. 9

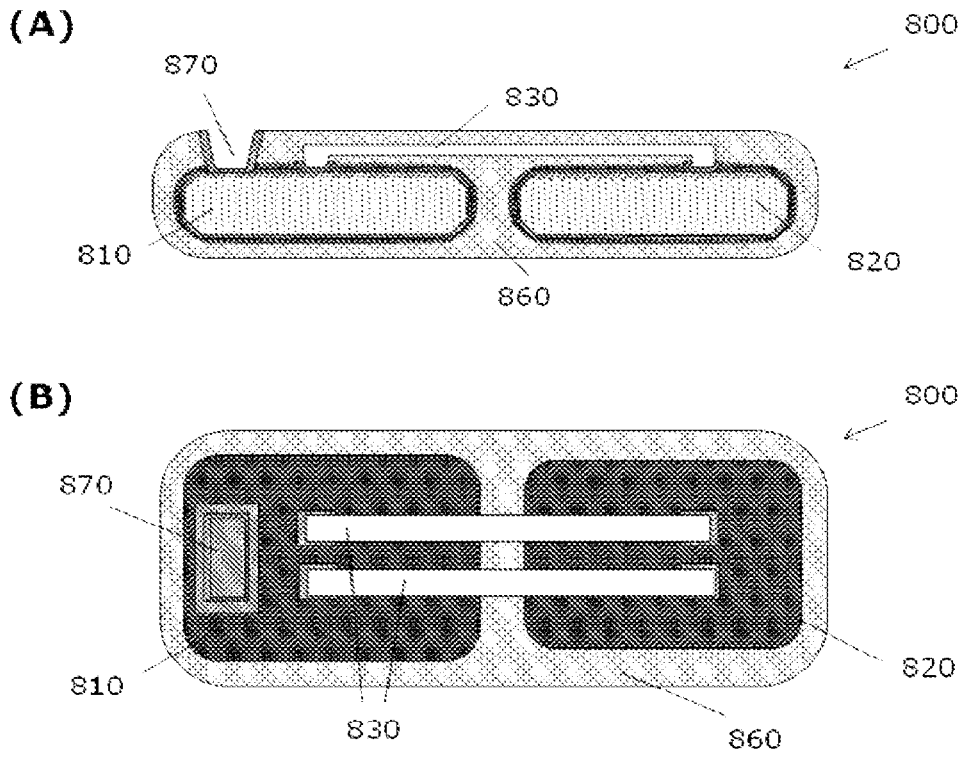


FIG. 10

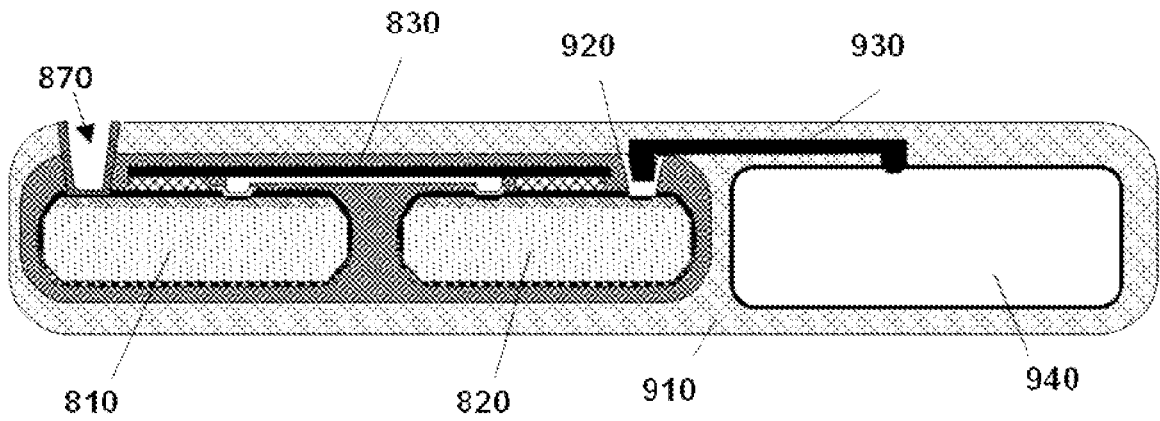


FIG. 11

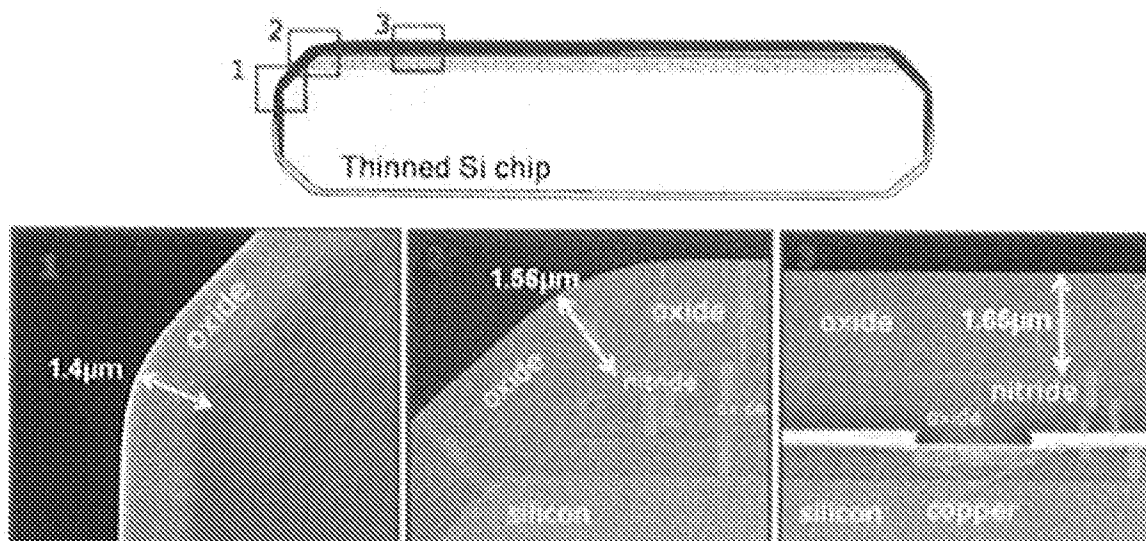


FIG. 12

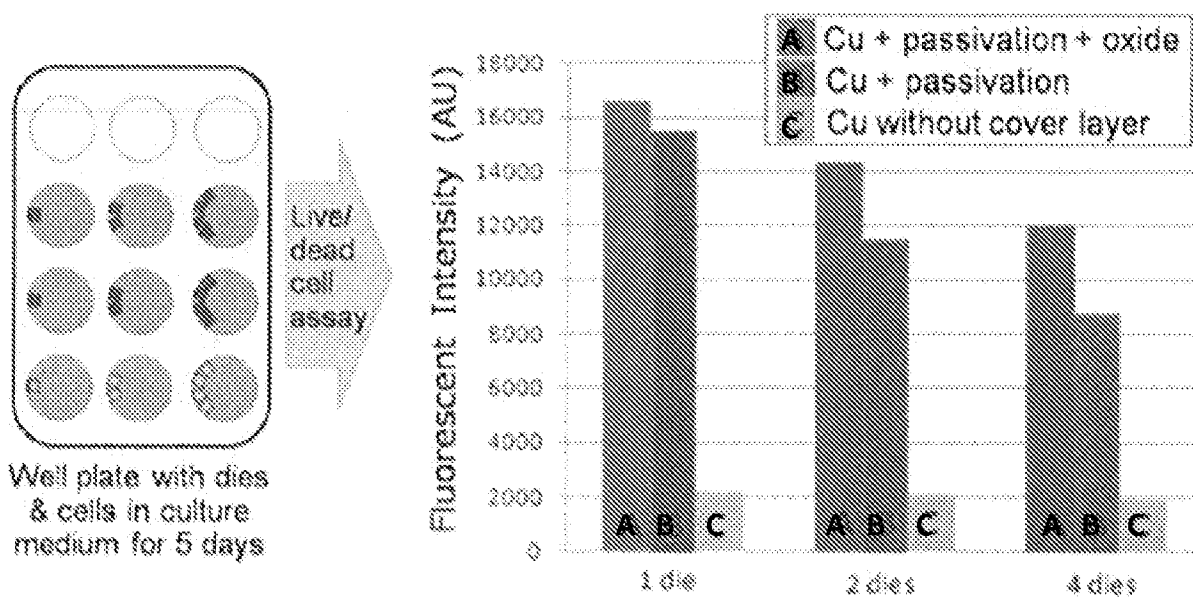


FIG. 13

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 7371693 B2 [0005]
- US 6482730 B1 [0006]

专利名称(译)	生物相容性包装		
公开(公告)号	EP2446478B1	公开(公告)日	2018-09-12
申请号	EP2010727416	申请日	2010-06-25
[标]申请(专利权)人(译)	校际微电子中心		
申请(专利权)人(译)	IMEC		
当前申请(专利权)人(译)	IMEC VZW		
[标]发明人	OP DE BEECK MARIA BEYNE ERIC SOUSSAN PHILIPPE		
发明人	OP DE BEECK, MARIA BEYNE, ERIC SOUSSAN, PHILIPPE		
IPC分类号	H01L23/00 H01L23/31 H01L29/06 A61B5/00 A61M5/142 A61N1/372 A61N1/375		
CPC分类号	A61B5/686 A61B5/6861 A61M5/14276 A61N1/37205 A61N1/375 A61N1/3756 H01L23/3114 H01L24/48 H01L2224/451 H01L2224/48227 H01L2924/00014 H01L2924/10253 H01L2924/14 H01L2924/1461 H01L2924/181 H01L2924/00 H01L2924/00015 H01L2224/05599 H01L2224/45099 H01L2224/45015 H01L2924/207 A61B2562/0247 A61B2562/028 A61M2205/0244 A61M2205/8206		
优先权	61/220528 2009-06-25 US		
其他公开文献	EP2446478A2		
外部链接	Espacenet		

摘要(译)

公开了一种用于包装例如用于生物医学应用的装置的方法。在一个方面，该方法包括在基板上获得部件，并使用至少一个物理过程将基板的第一部分与基板的第二部分分离，在第一部分上引入至少一个倾斜侧壁。基质。该方法还包括为芯片提供封装。所得到的封装芯片有利地具有良好的台阶覆盖，导致良好的气密性，较不锋利的边缘，导致植入后损坏或感染的风险降低，并且与传统的大盒子封装技术相比具有相对小的封装体积。

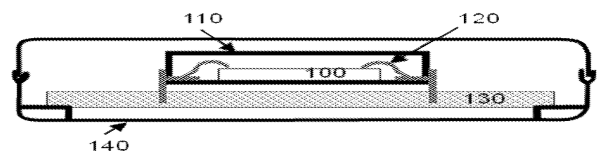


FIG. 1a

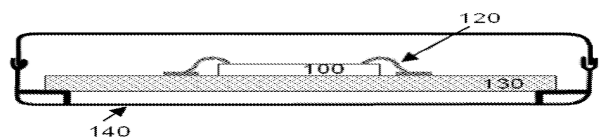


FIG. 1b