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(54) **ELECTRONIC DEVICES HAVING AN INORGANIC FILM**

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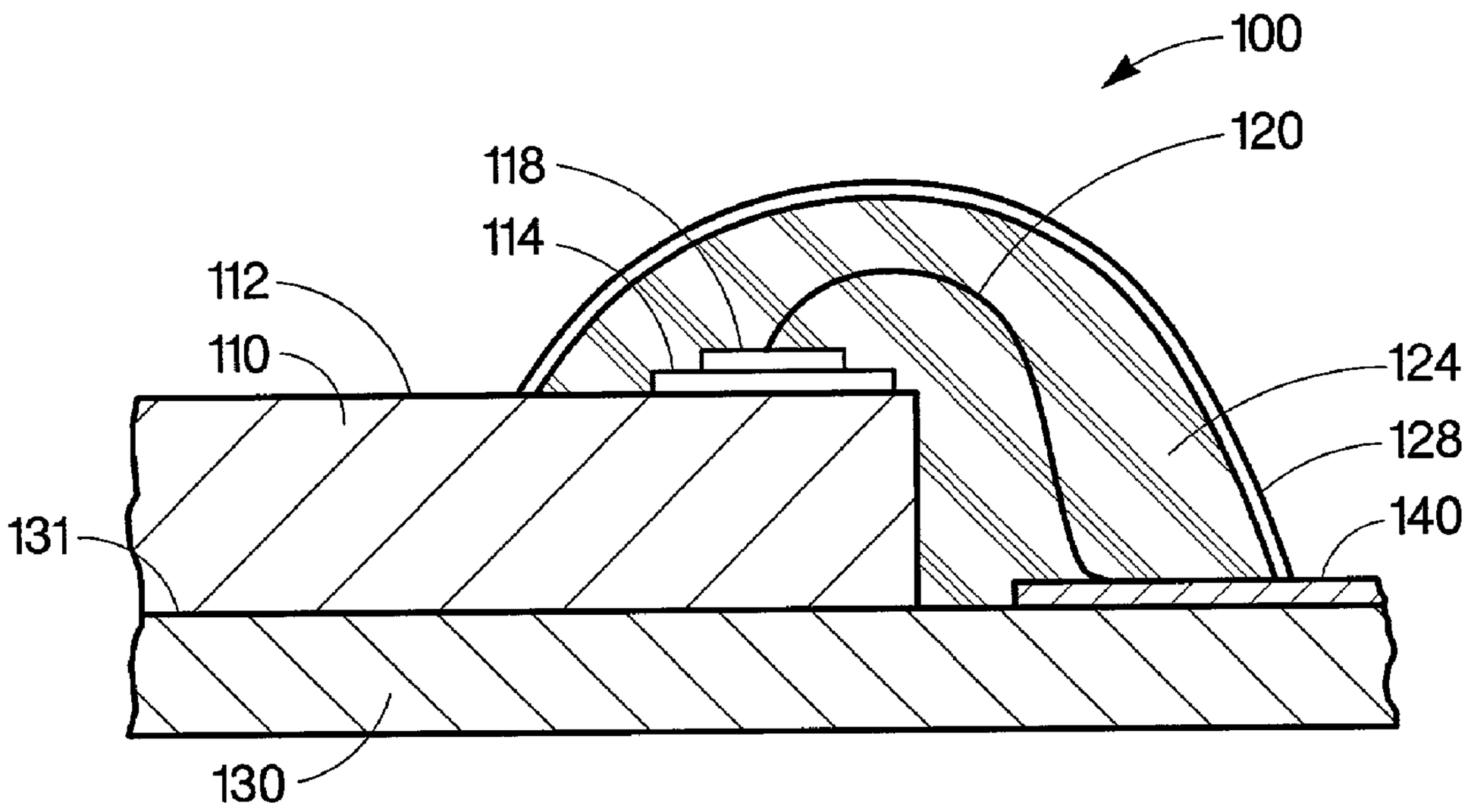
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(57) **ABSTRACT**

An electronic device includes a substrate, a substrate electrical connector disposed on the substrate, and a carrier lead electrically coupled to the substrate electrical connector. In addition, the electronic device further includes a polymer enclosing the substrate electrical connector, and an inorganic film disposed over the substrate electrical connector in contact with the polymer.



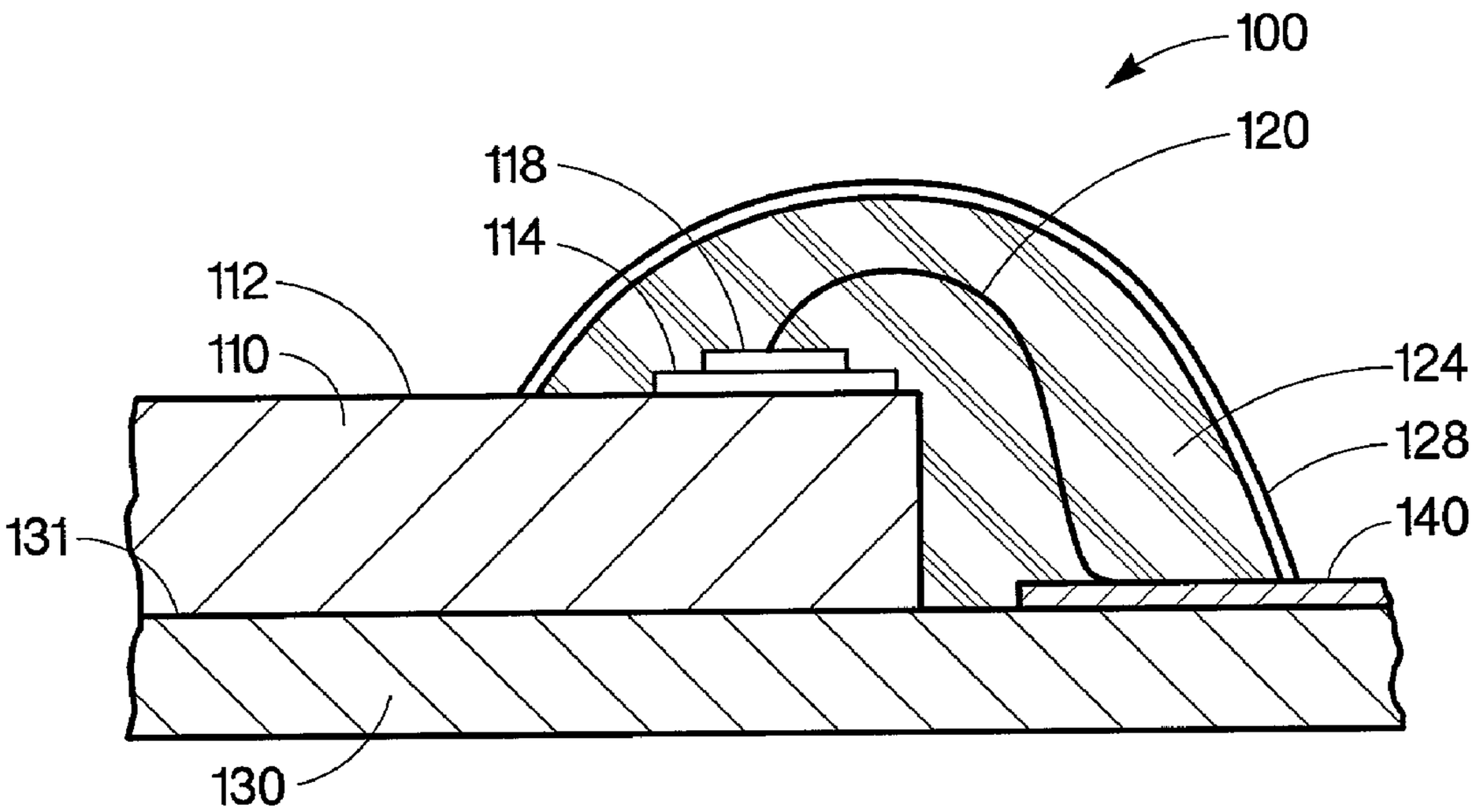


Fig. 1

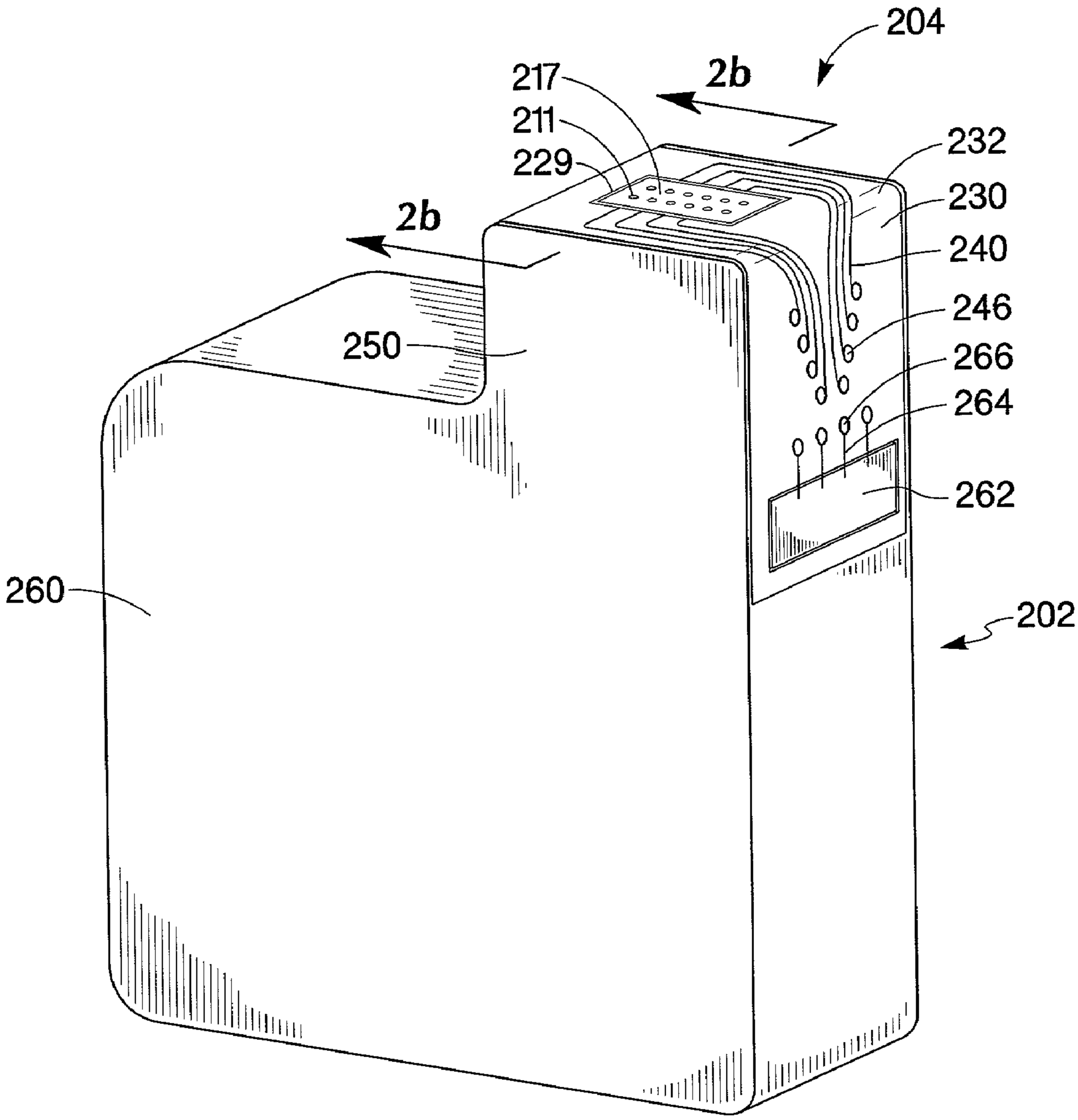


Fig. 2a

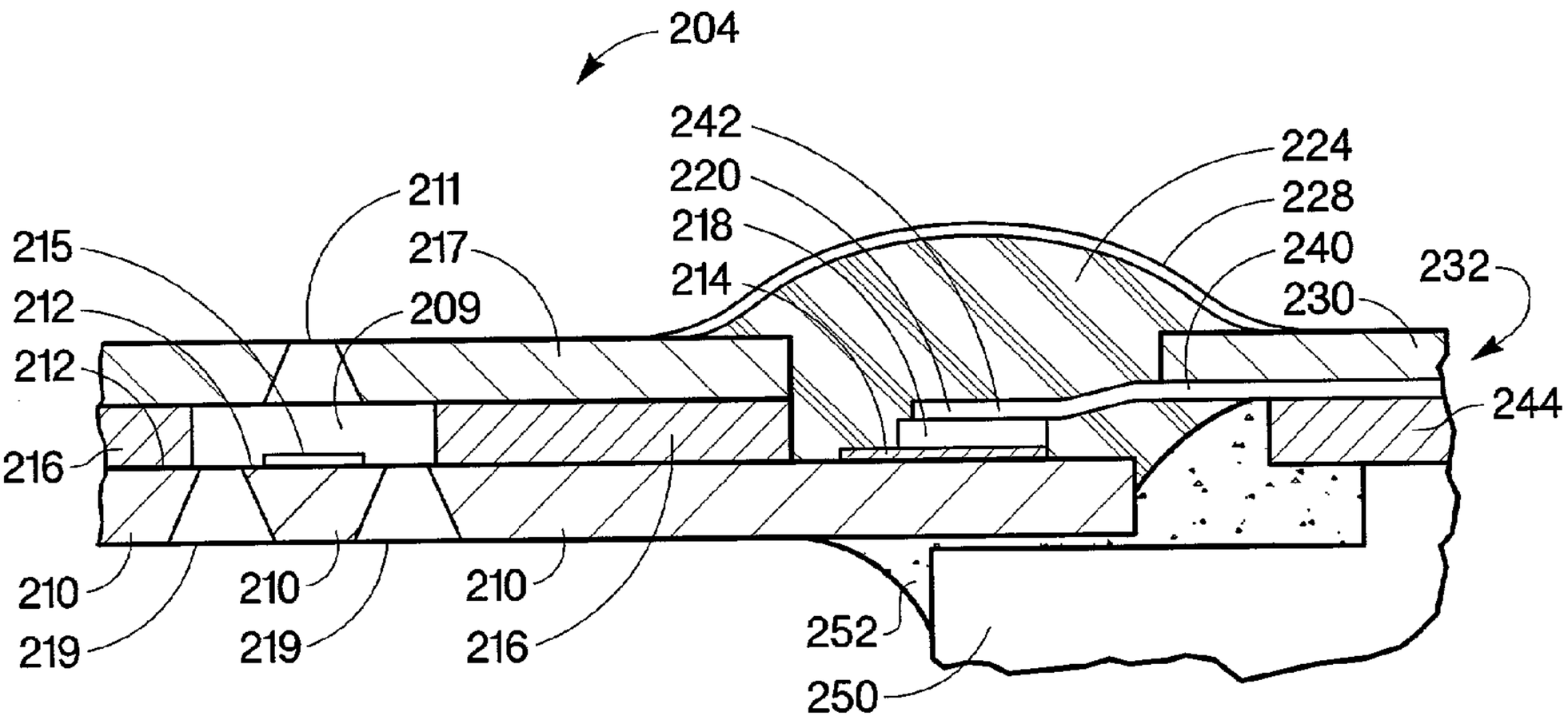

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Fig. 2b

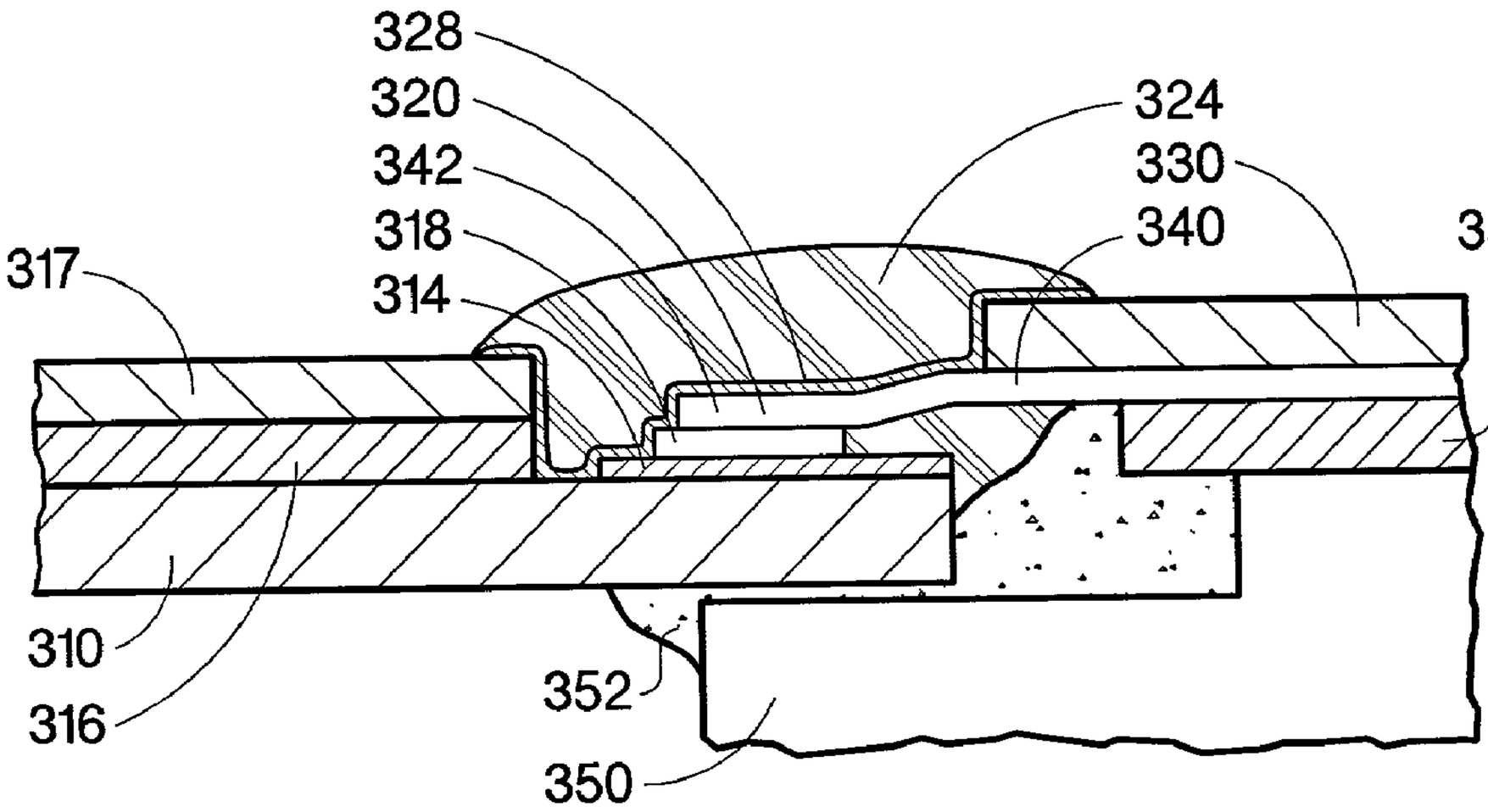


Fig. 3

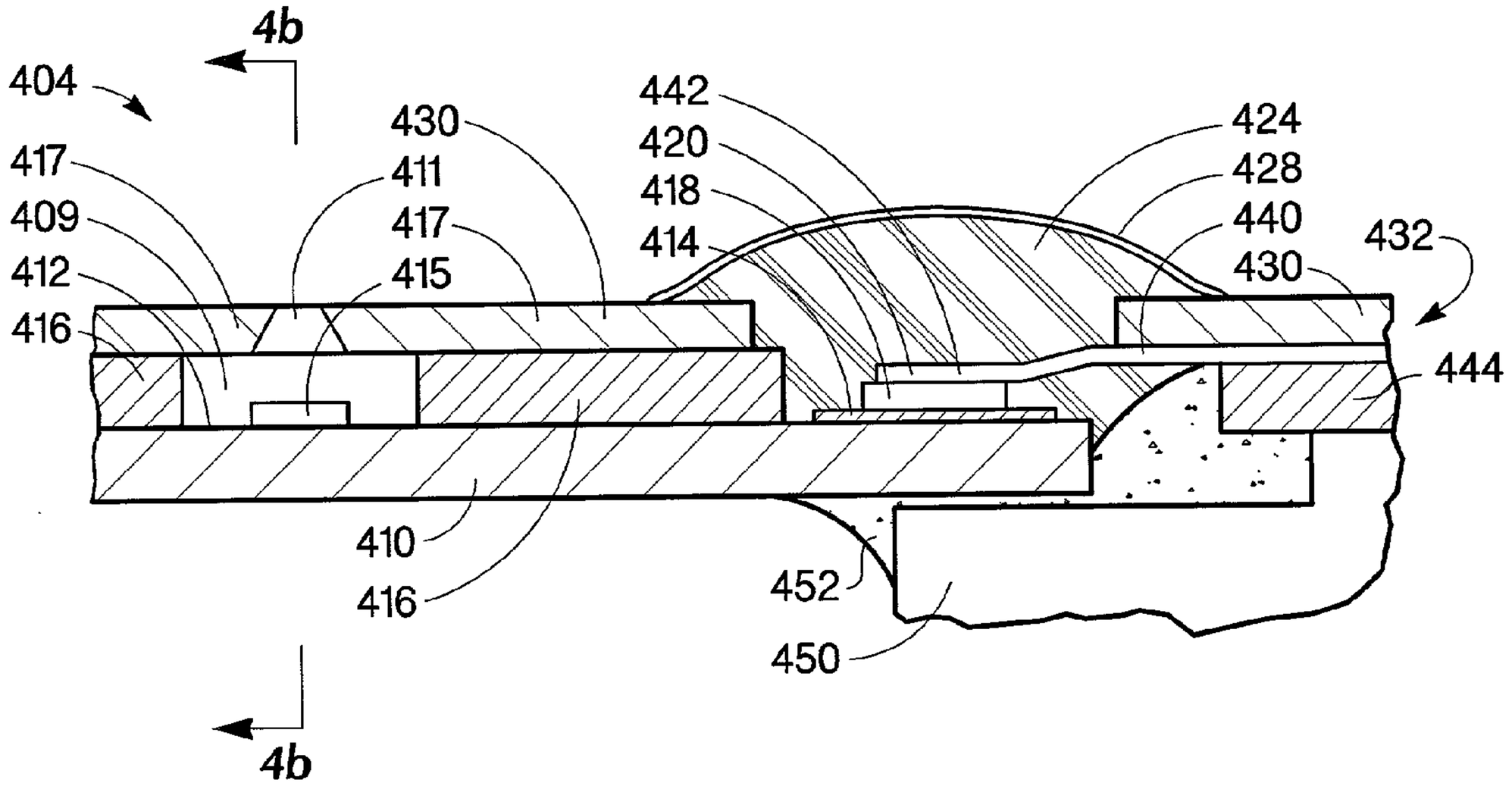

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Fig. 4a

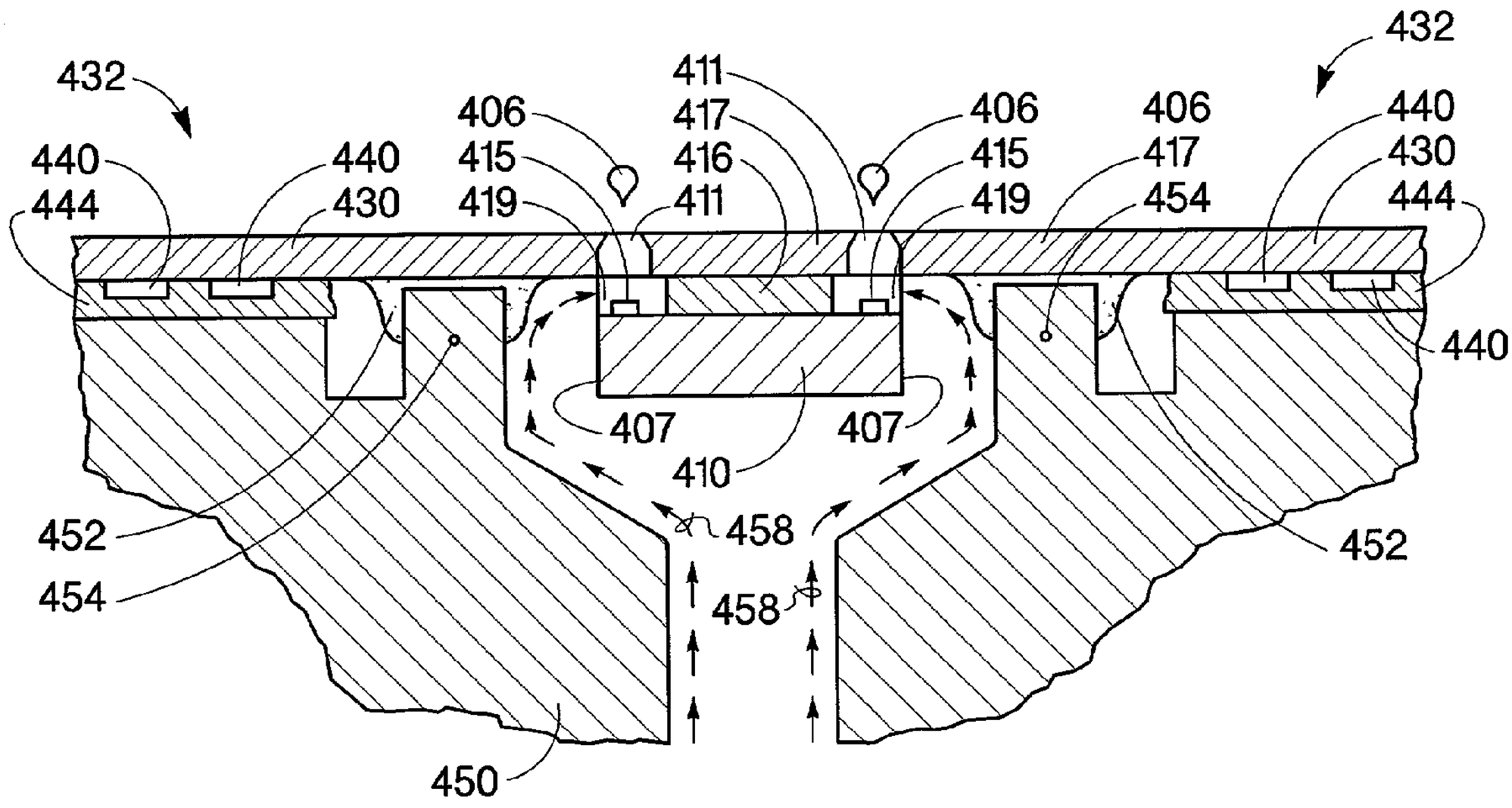

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Fig. 4b

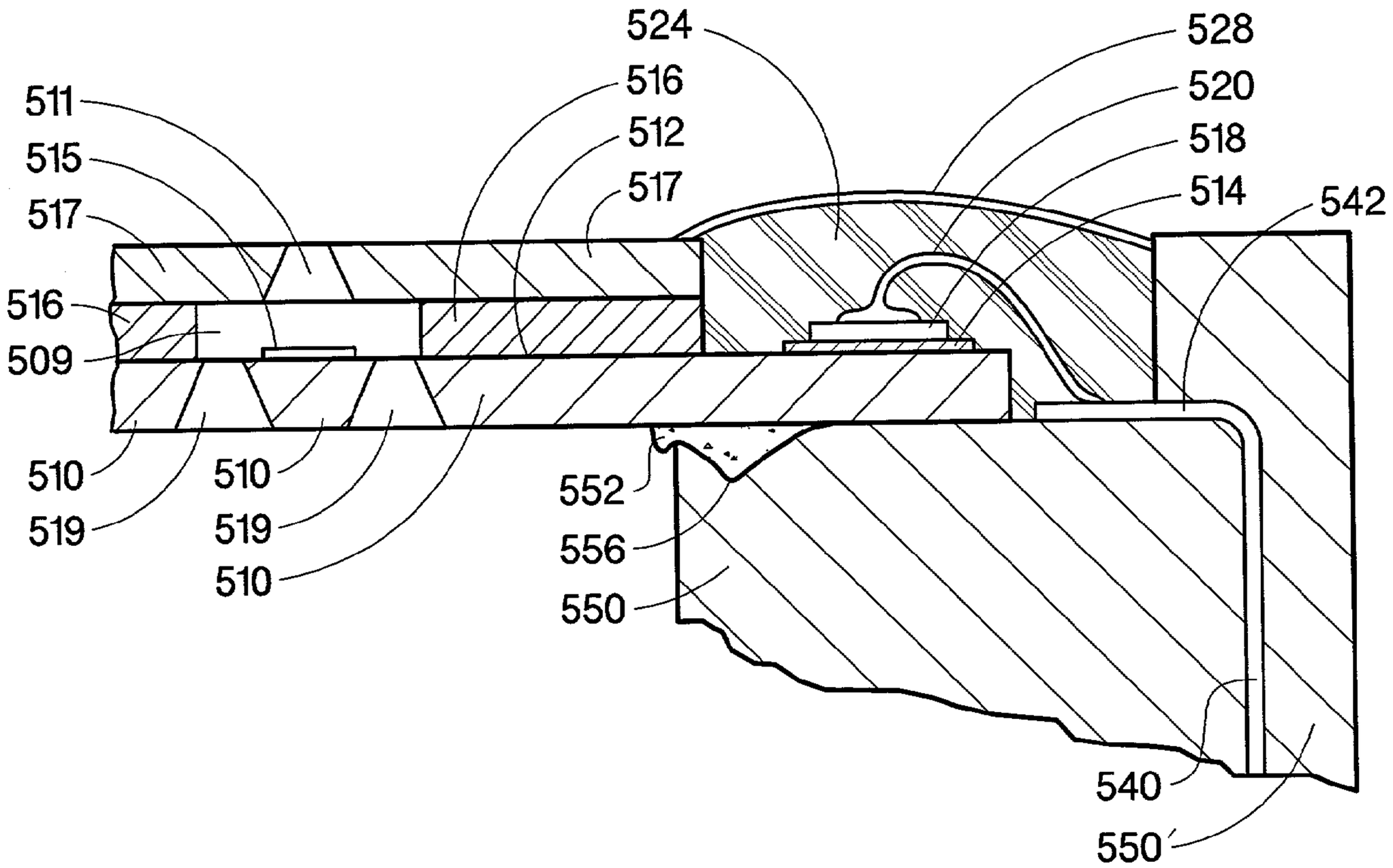

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Fig. 5

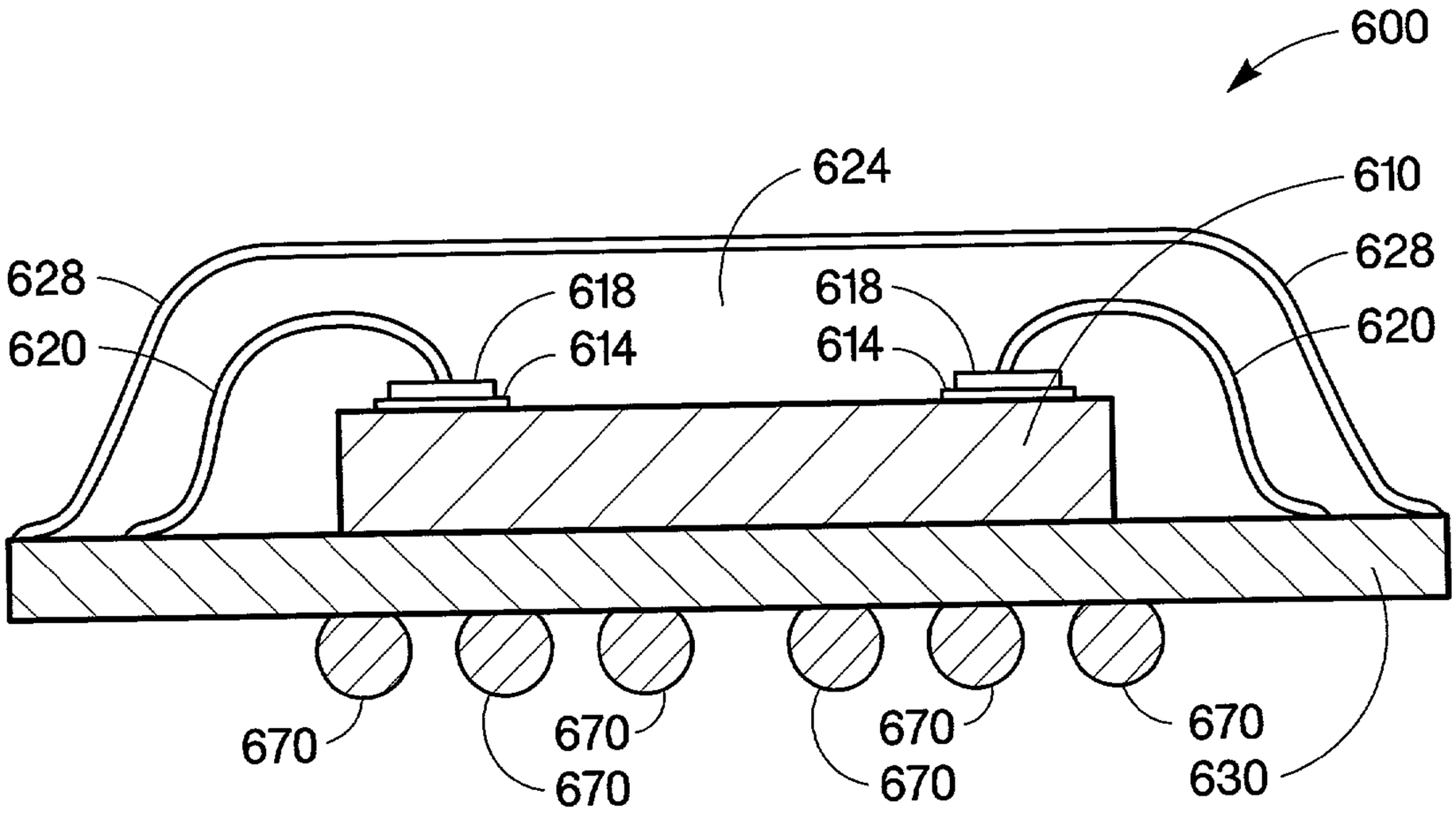

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Fig. 6

ELECTRONIC DEVICES HAVING AN INORGANIC FILM

BACKGROUND

DESCRIPTION OF THE ART

[0001] The increased utilization of electronic devices, in an ever widening array of diverse technologies, such as computers, automotive, medical, and household appliances has led to the operation of many of these electronic devices in harsh environments such as high humidity, high temperatures, or combinations thereof. In addition, there is also an increased demand for reliability. The continued improvement in performance and component density, of semiconductor devices, has led to a rapidly growing demand for packaging technologies to yield packaged devices having reduced cost, improved reliability and performance, increased interconnect density, and small package size.

[0002] Typically, a semiconductor device includes a semiconductor die with bond pads formed on its surface, and bond wires that electrically couple the bond pads with lead fingers on a lead frame. The semiconductor die is attached to the lead frame before bonding, and typically a polymer is dispensed or molded around the die, the bond wires, and the majority of the lead frame to encapsulate the device. The device is often electrically coupled with a printed circuit board (PCB) by soldering leads of the lead frame to pads on the PCB. The utilization of some encapsulating polymers can lead to performance degradation and damage from electrical shorting, corrosion, or cracking due to moisture. This tends to be an even greater problem when the electronic device must operate in a harsh environment.

[0003] Hermetic sealing using a metal or ceramic package provides an increased level of protection, however, the manufacturing process is complex and results in a more expensive package of increased size. Another method that can be utilized is sealing a semiconductor chip's active circuitry at the wafer stage, by applying a passivation coating over the active circuitry on the wafer. However, this process may still lead to a non-hermetically sealed device, by causing damage to the ceramic like coating in the vicinity of the bond pads in subsequent processing, thereby permitting corrosion to deleteriously affect chip reliability and life. Further, this process does not provide protection to the bond pads and electrical interconnections. In addition, these technologies do not lend themselves to all applications. For instance, over the past decade, substantial developments have been made in the micromanipulation of fluids, in fields such as electronic printing technology using inkjet printers. The ability to maintain reliable electrical interconnections in such products has become more difficult as the corrosive nature of the fluids increases.

[0004] An inkjet print cartridge provides a good example of the problems facing the practitioner in providing robust electrical interconnections to a semiconductor chip operating in a harsh environment. There are a wide variety of highly-efficient inkjet printing systems, currently in use, which are capable of dispensing ink in a rapid and accurate manner. Conventionally, electrical interconnections are made using a flexible circuit that has metal beams that extend out from the flexible substrate and are coupled to bond pads located on the inkjet chip. A polymer encapsulant is dispensed onto the coupled bond pads and beams and is then cured.

[0005] Ink jet cartridges typically include a fluid reservoir that is fluidically coupled to a substrate that is attached to the back of a nozzle layer containing one or more nozzles through which fluid is ejected. The substrate normally contains an energy-generating element that generates the force necessary for ejecting the fluid held in the reservoir. Two widely used energy generating elements are thermal resistors and piezoelectric elements. The former rapidly heats a component in the fluid above its boiling point causing ejection of a drop of the fluid. The latter utilizes a voltage pulse to generate a compressive force on the fluid resulting in ejection of a drop of the fluid.

[0006] In particular, improvements in image quality have led to the use of more complex ink formulations that generally increases the organic content of inkjet inks. The use of such inks, results in a more corrosive environment experienced by the materials coming in contact with these inks. Thus, degradation of the electrical interconnections by these more corrosive inks raises material compatibility issues as well as design issues in order to maintain reliable printheads. In addition, improvement in print speed has typically been gained by utilizing a larger printhead resulting in an increased print swath. The larger printhead typically results in a larger number energy generating elements, which can result in an increase number of electrical interconnections thereby exacerbating the problem. In addition, higher resolution may result in a larger number interconnects, closer spaced, with thinner organic passivation further contributing to reliability issues. Further, in an effort to reduce the cost and size of ink jet printers and to reduce the cost per printed page, printers have been developed having small, moving printheads that are connected to large stationary ink supplies. This development is called "off-axis" printing and has allowed the large ink supplies to be replaced as it is consumed without requiring the frequent replacement of the costly printhead containing the fluid ejectors and nozzle system. Thus, the typical "off-axis" system often utilizes a semi-permanent or permanent printhead that requires increased reliability and robustness of the electrical interconnections to maintain its optimal performance.

SUMMARY OF THE INVENTION

[0007] An electronic device includes a substrate, a substrate electrical connector disposed on the substrate, and a carrier lead electrically coupled to the substrate electrical connector. In addition, the electronic device further includes a polymer enclosing the substrate electrical connector, and an inorganic film disposed over the substrate electrical connector in contact with the polymer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] **FIG. 1** is a cross-sectional view of an electronic device according to an embodiment of the present invention;

[0009] **FIG. 2***a* is a perspective view of an electronic device according to an embodiment of the present invention;

[0010] **FIG. 2***b* is a cross-sectional view of an electronic device according to an embodiment of the present invention;

[0011] **FIG. 3** is a cross-sectional view of an electronic device according to an embodiment of the present invention;

[0012] **FIG. 4***a* is a cross-sectional view of an electronic device according to an embodiment of the present invention;

[0013] **FIG. 4***b* is a cross-sectional view of an electronic device according to an embodiment of the present invention;

[0014] **FIG. 5** is a cross-sectional view of an electronic device according to an embodiment of the present invention;

[0015] **FIG. 6** is a cross-sectional view of an electronic device according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0016] Referring to **FIG. 1**, an embodiment of the present invention is shown in a simplified cross-sectional view. In this embodiment, electronic device **100** includes inorganic layer **128** providing moisture and corrosion protection to electrical interconnection **120** and electrical connector **118**. Substrate **110** is disposed over base **130**, and includes dielectric layer **114** that is formed over at least a portion of substrate **110**, providing electrical isolation for one or more electrical connectors **118**. Preferably substrate **110** also includes one or more transistors or other logic devices (not shown) formed on substrate **110**. Electrical interconnection **120** electrically couples electrical connector **118** to carrier lead **140** providing signal as well as power connections to electronic device **100**. Inorganic film **128** is formed over polymer **124** that encloses electrical interconnection **120** and electrical connector **118**. The combination of inorganic film **128** and polymer **124** provides protection against environmental degradation as well as mechanical support to reduce damage of electrical interconnection **120** and electrical connector **118**.

[0017] Preferably, substrate **110** is a silicon integrated circuit, however, materials such as germanium, gallium arsenide, amorphous silicon, aluminum oxide, polysilicon, and other substrates that support active and passive devices can also be utilized. With reference to **FIG. 1** substrate **110** is preferably manufactured using a silicon wafer. Using conventional semiconductor processing equipment, transistors as well as other logic devices required for electronic device **100** are formed in substrate **110**. The particular structure of the transistors is not relevant to the present invention, however some type of solid state electronic device is preferably present, such as, metal oxide field effect transistors (MOSFET), bipolar junction transistors (BJT). Although **FIG. 1** shows only one electrical connector **118**, typically there are a plurality of electrical connectors positioned near opposed edges of substrate **110** that are connected to the transistors or other logic devices. The present invention as described herein is applicable irrespective of the electrical connector position on the substrate.

[0018] In this embodiment base **130** may be formed from metal, ceramic, or plastic materials or some combinations thereof. Materials suitable for base **130** include, metals, metal alloys, liquid crystal polymers, polyphenylene oxide, epoxy resins, polyimide resins, FR4 resins, aluminum oxide, and glass to name a few. For example, base **130** may be a metal lead frame, a ceramic die carrier, or a flexible circuit. In one embodiment, base **130** is a metal lead frame. Substrate **110** has an active surface **112** on which electronic components and electrical circuits are formed and an opposing surface **131**. Although **FIG. 1** shows substrate **110** coupled directly to base **130** a spacer layer (not shown) may also be utilized, depending on the particular application of electronic device **100**. The spacer or compliant layer provides stress relaxation related to the difference in the thermal expansion of the substrate and substrate carrier materials, thereby providing a wider choice of materials.

[0019] Dielectric layer **114** is formed over at least a portion of substrate **110** utilizing conventional semiconductor processing equipment. Preferably, dielectric layer **114** is silicon dioxide, however, other dielectric layers such as silicon nitride, silicon carbide, aluminum oxide, polyimides and other dielectric materials found in electronic devices can also be used. Electrical connector **118** is typically formed from a metal or metal alloy, such as aluminum or an aluminum alloy. In addition, some devices use pads or bumps formed from other metals and metal alloys such as copper, gold, silver, palladium and alloys of such metals. Preferably, electrical connector **118** is aluminum formed using conventional semiconductor deposition equipment; however, other techniques such as screen-printing or electroplating can also be utilized. Electrical interconnection **120** preferably is formed via wire bonding using lead wires formed from gold aluminum or alloys thereof. However, depending on the particular application of electronic device **100**, other interconnection schemes can also be utilized. For example, electrical interconnection **120** may be a solder bump for use in a ball grid array package. Another example is the use of a flexible substrate utilizing tape automated bonding (TAB) for electrical interconnection **120**. A further example is the use of a conductive adhesive or anisotropic conductive adhesive forming electrical interconnection **120**.

[0020] The exposed portions of electrical connector **118** and electrical interconnection **120** are enclosed or encapsulated by dispensing polymer **124**, a liquid encapsulation material. Preferably polymer **124** is a thermally cured or ultraviolet light (UV) cured epoxy. However, other materials such as polyimides or benzocyclobutenes can also be utilized. Inorganic layer **128** is formed over polymer encapsulant **124**, as shown in **FIG. 1**. Inorganic layer **128** can be essentially any thin inorganic layer such as thin metal or ceramic films. Preferably inorganic layer **128** is a metal such as tantalum or palladium having a thickness in the range from about 0.05 microns to about 0.5 microns. More preferably inorganic layer **128** includes a thin layer of chromium in the range from about 0.01 to about 0.02 microns thick and a tantalum layer in the range from about 0.05 microns to about 0.1 microns thick deposited over the chromium layer. However, a wide range of metals such as palladium, gold, tungsten, tantalum, chromium, aluminum, nickel, copper and alloys of such metals to name just a few can all be utilized. In addition, a wide range of ceramic like materials such as oxides, nitrides, carbides, borides, fluorides, and mixtures thereof can also be utilized. Although **FIG. 1** shows polymer **124** and inorganic layer **128** enclosing electrical connector **118** and electrical interconnection **120** in some applications it can be beneficial to enclose or encapsulate all of substrate **110** with polymer **124** and inorganic layer **128**. In addition, **FIG. 1** shows inorganic layer **128** disposed over polymer **124**, however inorganic layer **128** can also be deposited over electrical connector **118** and electrical interconnection **120**. In such an application inorganic layer **128** is a non-conductive material.

[0021] The adhesion between polymer **124** and inorganic layer **128** can be adjusted by pretreating the surface of polymer **124** before the formation or deposition of inorganic layer **128**. Preferably, either plasma treatment or corona

discharge treatment of polymer **124** with a reactive gas such as oxygen is used. However, other surface treatments such as laser, flame, chemical, or combinations thereof can also be utilized. In addition, a coupling agent can also be utilized by either incorporation in polymer **124** or by application to the surface of polymer **124** after dispensing.

[**0022**] Referring to **FIG. 2***a,* an exemplary embodiment of a fluid ejection cartridge **202** of the present invention is shown in a perspective view. In this embodiment, fluid ejection cartridge **202** includes reservoir **260** that contains a fluid, which is supplied to a substrate (not shown) that is secured to the back of nozzle layer **217**. Nozzle layer **217** contains one or more nozzles **211** through which fluid is ejected. Ejector head **204** includes the substrate (not shown), nozzle layer **217**, and nozzles **211**.

[**0023**] Flexible circuit **232** of the exemplary embodiment is a polymer film and includes electrical traces **240** connected to electrical contacts **246**. Electrical traces **240** are routed from electrical contacts **246** to electrical connectors or bond pads on the substrate (not shown) to provide electrical connection for the fluid ejection cartridge **202**. Encapsulation beads **229** are dispensed along the edge of nozzle layer **217** and the edge of the substrate enclosing the end portion of electrical traces **240** and the bond pads on the substrate.

[**0024**] Information storage element **262** is disposed on cartridge **202** as shown in **FIG. 2***a.* Preferably, information storage element **262** is electrically coupled to flexible circuit **232**. Information storage element **262** is any type of memory device suitable for storing and outputting information that may be related to properties or parameters of the fluid or ejector head **204**. Preferably, information storage element **262** is a memory chip mounted on flexible circuit **232** and electrically coupled through electrical traces **264** to electrical contacts **266**. Alternatively, information storage element **262** can be encapsulated in its own package with corresponding separate electrical traces and contacts. When fluid ejection cartridge **202** is either inserted into, or utilized in, a dispensing system information storage element **262** is electrically coupled to a controller that communicates with information storage element **262** to use the information or parameters stored therein. However, other forms of information storage can also be utilized for the information storage element **262**, such as a bar code or other device that allows storage of information.

[**0025**] A cross-sectional view of ejector head assembly **204** is shown **FIG. 2***b* showing inorganic layer **228** providing moisture and corrosion protection to electrical interconnection **220** and electrical connector or bond pad **218**. Substrate **210** has fluid ejector **215** formed on active surface **212**. Preferably fluid ejector **215** is a thermal resistor, however, other fluid ejectors may also be utilized such as piezoelectric, flex-tensional, acoustic, and electrostatic. In addition, substrate **210**, preferably, includes one or more transistors or other logic devices (not shown) formed on substrate **210**, however, "direct drive" structures can also be utilized. In a direct drive application each fluid ejector is electrically connected to a bond pad. Chamber layer **216** forms fluidic chamber **209** around fluid ejector **215** so that when fluid ejector **215** is activated fluid is ejected out of nozzle **211**, which is generally located over fluid ejector **215**. Fluid channels **219** formed in substrate **210** provides a fluidic path for fluid in reservoir **260** (See **FIG. 2***a*) to fill fluidic chamber **209**.

[**0026**] As shown in **FIG. 2***b,* nozzle layer **217** is formed over chamber layer **216**. Nozzle layer **217** may be formed of metal, polymer, glass, or other suitable material such as ceramic. In particular, a photodefinable polymer can be used to form both nozzle layer **217** and chamber layer **216**. For example, a photodefinable polyimide, benzocyclobutene, or epoxy can be utilized. Forming nozzle layer **217** and chamber layer **216** from a photoimagible epoxy available from MicroChem Corp. under the trademark NANO SU-8 is particularly preferable. However, other materials such as polyesters, polyethylene naphthalates (PEN), epoxies, or polycarbonates can also be utilized. In addition, nozzle layer **217** can also be formed from a metal such as a nickel base enclosed by a thin gold, palladium, tantalum, or rhodium layer.

[**0027**] Dielectric layer **214** is formed over at least a portion of substrate **210**, providing electrical isolation for one or more bond pads **218**. Preferably, substrate **210** is a silicon integrated circuit including transistors and other logic devices (not shown), however, materials such as germanium, gallium arsenide, amorphous silicon, aluminum oxide, polysilicon, and other substrates that support active and passive devices can also be utilized. Dielectric layer **214** and bond pad **218** are preferably formed utilizing conventional semiconductor equipment. Dielectric layer **214**, preferably, is a dual layer structure including silicon carbide and silicon nitride, with each layer having a thickness in the range from about 0.05 microns to 2.0 microns. However, other materials such as silicon oxide, siliconoxynitride, or aluminum oxide, and other thickness can also be utilized depending on the particular application of fluid ejection cartridge **202**.

[**0028**] Preferably a dual layer structure is utilized for bond pad **218**. A first metal layer comprising tantalum having a thickness in the range from about 0.075 microns to about 5.0 microns is deposited over dielectric layer **214**. A second metal layer comprising gold having a thickness in the range from about 0.1 microns to about 2.5 microns is deposited over the first metal layer. However, other metals and metal alloys can also be utilized such as aluminum and aluminum alloys. In addition, other thicknesses can also be utilized.

[**0029**] Flexible circuit **232** includes base film **230** and electrical traces **240** as shown in **FIG. 2***b.* Preferably, base film is formed from a polymer such as polyimide, polyester, or polyethylene naphthalate (PEN) to name a few. Examples of commercially available nozzle layer materials include a polyimide film available from E. I. DuPont de Nemours & Co. under the trademark "Kapton", a polyimide material available from Ube Industries, LTD (of Japan) under the trademark "Upilex." Flexible circuit **232** is formed utilizing techniques well known in the art such as conventional photolithographic etching, metal deposition, and electroplating processes. Preferably, flexible circuit **232** is processed in a tape form using reel-to-reel processing equipment.

[**0030**] Electrical interconnection **220**, preferably, is formed utilizing a conventional TAB bonder, such as an inner lead bonder commercially available from Shinkawa Corporation. The bonder applies pressure to electrical trace end **242** pressing trace end **242** onto bond pad **218** through the opening formed by the end of nozzle layer **217** and the

end of base film **230**. The bonder applies heat, to form a thermocompression bond thereby forming electrical interconnection **220**. Other types of bonding can also be utilized, such as ultrasonic bonding, conductive adhesive, solder paste, or other electrical bonding technologies.

[**0031**] To provide mechanical support as well as environmental protection a polymer bead **224**, such as an epoxy, is dispensed so that the dispensed polymer **224** encloses electrical interconnection **220**, bond pad **218**, and electrical trace end **242**. Preferably polymer **224** is a thermally cured or ultraviolet light (UV) cured epoxy dispensed in a liquid form through a needle dispenser. However, other materials such as polyimides, benzocyclobutenes, and polyacrylates can also be utilized.

[**0032**] Inorganic film **228** is formed over polymer bead **224**, preferably, utilizing conventional thin film deposition equipment, such as thermal or electron beam evaporators, sputter deposition systems, or chemical vapor deposition systems. However, other thin film deposition technologies can also be utilized such as electroless deposition, electroplating, or screen printing are just a few examples. Inorganic film **228** can be essentially any thin inorganic layer such as a thin metal or ceramic film. Preferably inorganic film **228** is a metal such as tantalum, platinum, or gold having a thickness in the range from about 0.05 microns to about 1.0 micron. More preferably inorganic layer **128** includes a thin layer of chromium in the range from about 0.01 microns to 0.02 microns thick and a tantalum layer in the range from about 0.1 microns to about 0.75 microns thick deposited over the chromium layer. However, a wide range of metals such as palladium, gold, tungsten, aluminum, tantalum, chromium, nickel, titanium, copper, and alloys of such metals to name just a few can all be utilized. In addition, a wide range of ceramic like materials such as oxides, nitrides, carbides, borides, fluorides, and mixtures thereof can also be utilized. Silicon oxide and silicon nitride having a thickness in the range from about 0.1 microns to about 0.5 microns are two examples of ceramic like materials that are preferable.

[**0033**] The adhesion between polymer **224** and inorganic layer **228** can be adjusted by pre-treating the surface of polymer **224** before the formation or deposition of inorganic layer **228**. Preferably, either plasma treatment or corona discharge treatment of polymer **224** with a reactive gas such as oxygen is used. However, other surface treatments such as laser, flame, chemical, or combinations thereof can also be utilized. In addition, a coupling agent can also be utilized by either incorporation in polymer **224** or by application to the surface of polymer **224** after dispensing.

[**0034**] Adhesive **252** is dispensed around the periphery of substrate **210** providing both a method of attachment and a fluid seal between substrate **210** and fluid ejection body **250**. Preferably adhesive **252** is a thermally cured epoxy, however, other adhesives such as hot melt, silicone, UV curable, and mixtures thereof can also be utilized. Further, a patterned adhesive film may be positioned on either fluid ejection body **250** or substrate **210**, as opposed to dispensing a bead of adhesive.

[**0035**] Coverlayer **244** is heat staked to fluid ejection body **250** providing an adhesive function to attach flexible circuit **232** (shown in **FIG. 2**) to fluid ejection body **250** as well as providing environmental protection of electrical traces **240**. Preferably coverlayer **244** is a three-layer laminate with a 1.5 mil ethyl vinyl acetate (EVA), a 0.5 mil polyethylene terephthalate (PET) layer, and a 1.5 mil ethyl vinyl acetate layer. EVA is a thermoplastic material, which reflows upon heating and bonds to fluid ejection body **250**. The PET film acts as a carrier layer that allows mechanical punching and handling of coverlayer **244** without excessive stretching. In some applications a single layer can also be utilized such as a single layer of EVA, polyolefin, or acrylic acid copolymers to name a few.

[**0036**] Referring to **FIG. 3** an alternate embodiment of the present invention is shown, in a cross-sectional view where polymer **324** is formed over inorganic layer **328**, which is formed over bond pad **318**, and electrical interconnection **320**. In this embodiment, inorganic layer **328** is formed from a non-conductive material or hermetic material such as oxides, nitrides, carbides, borides, fluorides, and mixtures thereof. Preferably, inorganic layer **328** is deposited, as a thin film having a thickness in the range from about 0.1 microns to about 0.5 microns, utilizing conventional thin film deposition equipment, such, sputter deposition systems, chemical vapor deposition systems, or plasma enhanced chemical vapor deposition systems. As shown in **FIG. 3***a* inorganic layer **328** is deposited essentially within the opening formed by the end of nozzle layer **317** and the end of base film **330** and preferably extending a short distance, on the order of a few microns, over the end portion of both nozzle layer **317** and base film **330**. The particular length that inorganic layer **328** extends over nozzle layer **317** and base film **330** depends on for example the particular material used, the method of deposition, and fluid ejected. In addition, the thickness of inorganic layer **328** also depends on the particular materials used, the method of deposition and the uniformity in step coverage obtained under the deposition conditions.

[**0037**] Referring to **FIG. 4** an alternate embodiment of the present invention is shown, in a cross-sectional view where nozzle layer **417** and base film **430** form an integrated nozzle layer and flexible circuit. In this embodiment, ejector head **404** includes substrate **410**, nozzle **411**, and base film **430** that includes nozzle layer **417**. Nozzle layer **417** contains one or more nozzles **411** through which fluid is ejected. The nozzle layer **417** may be formed from a polymer, preferably, a polymer such as polyimide, polyester, polyethylene naphthalate (PEN), epoxy, or polycarbonate. Examples of commercially available nozzle layer materials include a polyimide film available from E. I. DuPont de Nemours & Co. under the trademark "Kapton", or a polyimide material available from Ube Industries, LTD (of Japan) under the trademark "Upilex." Nozzles **411** are formed by any of the techniques well known in the art, such as laser ablation, plasma etching, or chemical etching. In this embodiment all of the structures, such as fluid channel layer **416**, coverlayer **444**, and bond pad **418** have substantially the same function as illustrated and described in **FIG. 2***b*.

[**0038**] Flexible circuit **432** includes base film **430** and electrical traces **440**. Dielectric layer **414** is formed over at least a portion of substrate **410**, providing electrical isolation for one or more bond pads **418**. Bond pad **418**, as described above, preferably, is formed as a dual layer structure. To provide mechanical support as well as environmental protection polymer bead **424**, such as an epoxy, is dispensed so that dispensed polymer **424** encloses electrical interconnection **420**, bond pad **418**, and electrical trace end **442**.

Inorganic film **428** is formed over polymer bead **424** as described above. The materials, processes and equipment utilized can be substantially the same as that described for the embodiment shown in **FIGS. 2***a* and **2***b*. In addition, inorganic film **428** may also be formed over bond pad **418**, and electrical interconnection **420** as illustrated in **FIG. 3**.

[**0039**] In this embodiment, fluid **458** flows around edges **407** of substrate **410** and directly into fluid channels **419** as shown in a cross-sectional view in **FIG. 4***b*. When fluid ejectors **415** are activated, fluid over the fluid ejectors **415** is ejected out of nozzles **411** as illustrated by drops **406**. Adhesive **452** is shown applied to inner raised wall **454** of fluid ejection body **450** forming a portion of the fluid seal. Fluid channel layer **416**, preferably is bonded to nozzle layer **417** through a heat staking process, however, a thin adhesive layer between nozzle layer **417** and fluid channel layer **416** may also be used. In addition, a portion of flexible circuit **430** is preferably heat staked via coverlayer **444** to plastic fluid ejection body **450** is also shown in **FIG. 4***b*. Coverlayer **444** also encloses electrical traces **440** of flexible circuit **432**.

[**0040**] Referring to **FIG. 5** an alternate embodiment of the present invention is shown in a cross-sectional view where electrical interconnection **520** is formed utilizing a wire bond. In this embodiment, electrical traces **540** are either formed in fluid ejection body **550** and **550'** or outer portion **550'** is adhesively or mechanically attached to fluid ejection body **550** to provide mechanical and environmental protection of electrical traces **540**. Preferably, electrical traces **540** are formed utilizing molded interconnect technology, however other electrical trace routing schemes such as FR-4 board, lead frames, flexible circuits, and combinations of routing schemes can also be utilized. Ultrasonic ball-wedge bonding is preferred, however, other bonding technologies can also be utilized such as thermocompression or thermosonic bonding coupled with wedge-wedge or ball-wedge techniques. In this embodiment, structures, such as fluid channel layer **516**, substrate **510**, and bond pad **518** have substantially the same function as illustrated and described above.

[**0041**] In this embodiment, fluid channels **519** formed in substrate **510** provide a fluidic path to fill fluidic chamber **509**. When fluid ejectors **515** are activated, fluid over the fluid ejectors **515** is ejected out of nozzles **511**. Adhesive **552** is shown applied to adhesive channel **556** of fluid ejection body **550** forming a fluid seal with substrate **510**. To provide mechanical support as well as environmental protection polymer bead **524**, such as an epoxy, is dispensed so that dispensed polymer **524** essentially encloses electrical interconnection **520**, bond pad **518**, and electrical trace end **542**. Inorganic film **528** is formed over polymer bead **524** as described above. In addition, inorganic film **528** may also be formed over electrical conductor **518** and electrical interconnection **520** as described for the embodiments shown in FIGS. **1** and **3**. The materials, processes and equipment may be substantially the same as that described above.

[**0042**] Referring to **FIG. 6** an alternate embodiment of the present invention is shown in a simplified cross-sectional view where electronic device **600** includes base film **630** that provides rerouting of electrical interconnection **620** to solder balls **670** forming what is commonly referred to as a ball grid array (BGA). The details of the rerouting structures as well as the electrical connection of electrical interconnection **620** to those structures has been omitted to simplify the drawing. Dielectric layer **614** and bond pads **618** are formed in a manner similar to that described above. In this embodiment electrical interconnection **620**, preferably is a wire bond, however other bonding schemes such as conductive adhesives, and anisotropic conductive adhesives can also be utilized. Preferably, base film **630** is a flexible circuit, however, other substrates utilized for electrical trace routing can also be utilized such as FR-4 board or a ceramic die carrier. In addition base film **630** may also be a multi-layered structure providing for an increased number of interconnects while keeping the footprint of the package small. Polymer **624** is a molded encapsulant, preferably an epoxy; however, other polymers may also be utilized such as polycarbonates, polyimides, and benzocyclobutenes to name a few. Preferably, molded polymer **624** is formed utilizing conventional tooling used for molded parts well known in the art of electronic packaging. Inorganic film **628** is formed over molded polymer encapsulant **624** as described above. The materials, processes and equipment may be substantially the same as that described above.

What is claimed is:

1. An electronic device comprising:

a substrate;

a substrate electrical connector disposed on said substrate;

a carrier lead electrically coupled to said substrate electrical connector;

a polymer enclosing said substrate electrical connector; and

an inorganic film disposed over said substrate electrical connector and said inorganic film contacts said polymer.

2. The electronic device of claim 1, further comprising at least one active device disposed on said substrate.

3. The electronic device of claim 2, further comprising an electrical trace coupling said at least one active device and said substrate electrical connector.

4. The electronic device of claim 1, wherein said substrate includes at least one fluid ejector.

5. The electronic device of claim 4, further comprising an electrical trace coupling said at least one fluid ejector and said substrate electrical connector.

6. The electronic device of claim 4, wherein said at least one fluid ejector further comprises at least one thermal resistor.

7. The electronic device of claim 1, wherein said carrier electrical trace is TAB bonded to said substrate electrical connector.

8. The electronic device of claim 1, further comprising a carrier bond pad electrically coupled to said substrate electrical connector.

9. The electronic device of claim 8, wherein said carrier bond pad is wire bonded to said substrate electrical connector.

10. The electronic device of claim 8, wherein said carrier bond pad is bonded to said substrate electrical connector using solder.

11. The electronic device of claim 8, wherein said carrier bond pad is adhesively bonded to said substrate electrical connector using a conductive adhesive.

12. The electronic device of claim 11, wherein said conductive adhesive is an anisotropically conductive adhesive.

13. The electronic device of claim 1, wherein said inorganic film is selected from the group consisting of a metal, an oxide, a nitride, a carbide, and mixtures thereof.

14. The electronic device of claim 1, wherein said inorganic film includes at least one of a metal, an oxide, a nitride, and a carbide.

15. The electronic device of claim 1, wherein said polymer includes a treated surface utilizing a surface treatment.

16. The electronic device of claim 15, wherein said surface treatment is selected from the group consisting of a plasma treatment, a corona discharge, a flame treatment, a laser treatment, a chemical treatment, or combinations thereof.

17. The electronic device of claim 1, wherein said inorganic film is in the range of about 0.05 microns to about 1.0 micron thick.

18. An electronic device comprising:

a substrate;

a substrate electrical connector disposed on said substrate;

a carrier lead electrically coupled to said substrate electrical connector;

a polymer enclosing said substrate electrical connector;

an inorganic film disposed over said substrate electrical connector and said inorganic film contacts said polymer, wherein said inorganic film is in the range of about 0.05 microns to about 1.0 microns thick;

at least one active device disposed on said substrate; and

an electrical trace coupling said at least one active device and said substrate electrical connector.

19. A fluid ejection head comprising:

a substrate including:

at least one fluid ejector disposed thereon; and

a dielectric layer disposed over at least a portion of said substrate;

a substrate electrical connector in contact with said dielectric layer;

a substrate carrier including a carrier electrical trace electrically coupled to said substrate electrical connector;

a polymer enclosing said substrate electrical connector; and

an inorganic film disposed over said substrate electrical connector in contact with said polymer.

20. The fluid ejection head of claim 19, further comprising:

at least one transistor disposed on said substrate; and

an electrical trace electrically coupling said at least one transistor to said at least one fluid ejector.

21. The fluid ejection head of claim 19, wherein said carrier electrical trace is TAB bonded to said substrate electrical connector.

22. The fluid ejection head of claim 19 above, wherein said substrate carrier is selected from the group consisting of a polyimide film, a polyester film, a polyester napthalate film, or combinations thereof.

23. The fluid ejection head of claim 19 above, wherein said substrate carrier is selected from the group consisting of a polyimide, a polyester, a polyester napthalate, or mixtures thereof.

24. The fluid ejection head of claim 19 above, further comprising a carrier bond pad electrically coupled to said substrate electrical connector.

25. The fluid ejection head of claim 24 above, wherein said carrier bond pad is wire bonded to said substrate electrical connector.

26. The fluid ejection head of claim 24 above, wherein said carrier bond pad is adhesively bonded to said substrate electrical connector using a conductive adhesive.

27. The fluid ejection head of claim 26, wherein said conductive adhesive is an anisotropic conductive adhesive.

28. The fluid ejection head of claim 19, wherein said polymer is selected from the group consisting of an epoxy, an acrylic, a polyimide and mixtures thereof.

29. The fluid ejection head of claim 19, wherein said inorganic film is selected from the group consisting of a metal, a oxide, a nitride, a carbide or combinations thereof.

30. The fluid ejection head of claim 19, wherein said inorganic film is selected from the group consisting of a metal, a oxide, a nitride, a carbide or mixtures thereof.

31. The electronic device of claim 19, wherein said polymer includes a treated surface utilizing a surface treatment.

32. The electronic device of claim 31, wherein said surface treatment is selected from the group consisting of a plasma treatment, a corona discharge, a flame treatment, a laser treatment, a chemical treatment, or combinations thereof.

33. The fluid ejection head of claim 19, wherein said inorganic film is in the range of about 0.05 microns to about 1.0 micron thick

34. A fluid ejection cartridge comprising:

at least one fluid ejection head of claim 19; and

at least one reservoir fluidically coupled to said at least one fluid ejection head.

35. A fluid ejection head comprising:

a substrate including:

at least one fluid ejector disposed thereon; and

a dielectric layer disposed over at least a portion of said substrate;

a substrate electrical connector in contact with said dielectric layer;

a substrate carrier including a carrier electrical trace electrically coupled to said substrate electrical connector;

a polymer enclosing said substrate electrical connector;

an inorganic film disposed over said substrate electrical connector in contact with said polymer, wherein said inorganic film is in the range of about 0.05 microns to about 1.0 micron thick;

at least one transistor disposed on said substrate; and

an electrical trace electrically coupling said at least one transistor to said at least one fluid ejector.

36. A method of manufacturing a fluid ejection head comprising the steps of:

fabricating at least one fluid ejector on a substrate;

forming a substrate electrical connector on said substrate;

positioning a substrate carrier including a carrier electrical trace in proximity to said substrate;

electrically coupling said electrical trace to said substrate electrical connector;

encapsulating said substrate bond bad; and

depositing an inorganic film over said substrate electrical connector.

37. The method of claim 36, further comprising the steps of:

forming at least one transistor on said substrate; and

electrically coupling said at least one fluid ejector to said at least one transistor.

38. The method of claim 36, wherein said depositing step further comprises the step of protecting said substrate electrical connector from moisture.

39. The method of claim 36, wherein said depositing step further comprises the step of protecting said substrate electrical connector from corrosion.

40. The method of claim 36, wherein said step of electrically coupling said carrier electrical trace to said substrate electrical connector further comprises the step of TAB bonding an electrical beam of said carrier electrical trace to said substrate electrical connector.

41. The method of claim 36, wherein said step of electrically coupling said carrier electrical trace to said substrate electrical connector further comprises the step of utilizing a conductive adhesive to electrically couple said carrier electrical trace to said substrate electrical connector.

42. The method of claim 36, wherein said step of electrically coupling said carrier electrical trace to said substrate electrical connector further comprises the step of utilizing an anisotropic conductive adhesive to electrically couple said carrier electrical trace to said substrate electrical connector.

43. A method of manufacturing a fluid ejection head comprising the steps of:

fabricating at least one fluid ejector on a substrate;

forming a substrate electrical connector on said substrate;

positioning a substrate carrier including a carrier electrical trace in proximity to said substrate;

electrically coupling said electrical trace to said substrate electrical connector;

encapsulating said substrate bond bad;

depositing an inorganic film over said substrate electrical connector, wherein said inorganic film is in the range of about 0.05 microns to about 1.0 micron thick;

forming at least one transistor on said substrate; and

electrically coupling said at least one fluid ejector to said at least one transistor.

44. An electronic device comprising:

a substrate;

a carrier;

means for electrically coupling said carrier to said substrate;

means for enclosing said electrical connection to said substrate; and

an inorganic film disposed over said means for electrically coupling, wherein said inorganic film is in contact with said means for enclosing said electrical connection to said substrate.

45. The electronic device of claim 44, further comprising a means for modifying a signal.

46. The electronic device of claim 44, further comprising a means for ejecting a fluid.

47. A method of manufacturing an electronic device comprising the steps of:

forming a substrate electrical connector on a substrate;

electrically coupling a carrier lead to said substrate electrical connector;

encapsulating said substrate electrical connector using an encapsulant; and

depositing an inorganic film over said substrate electrical connector in contact with said encapsulant.

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