PACKAGING SYSTEM WITH HOLLOW PACKAGE AND METHOD FOR THE SAME

TECHNICAL FIELD

The present invention relates generally to integrated circuit packaging, and more particularly to a system for packaging integrated circuits and micro-electromechanical systems.

BACKGROUND ART

In the highly integrated world of cell phones, digital recording devices and personal audio players, micro-electromechanical systems and integrated circuits play a key role. These miniature devices allow functional integration to achieve extremely small form factors.

MEMS devices are typically made on silicon wafers; using one of two well established techniques: bulk micro-machining or surface micro-machining. In both of these methods, the MEMS device is fabricated on a silicon wafer using standard IC-type fabrication equipment. Once the wafer is processed, the wafer is diced to form individual die. These MEMS die may or may not be integrated with electronic components (on CMOS). Once the die is singulated, it must then be packaged in some form of package, similar to an IC package. This package is eventually inserted into a socket or bonded to a Printed Circuit Board (PCB) as part of an overall system, i.e., a cell phone. These packages can be quite elaborate, depending on the MEMS style and application, including vacuum package requirements. In addition, because many MEMS devices are required to move during operation, the package must provide a cavity that allows for this movement.

One problem with this type of MEMS packaging methodology is that the package is a very large proportion of the total MEMS device cost; on the order of 30 to 70% of the overall cost. This packaging cost can, therefore, have a significant impact on the capability of such MEMS devices to penetrate cost-sensitive markets, such as the cell phone market.

Another problem with existing MEMS packaging is the noise inherent with the electrical connections between the MEMS package and the rest of the system. The bonding, wiring, and electrical interconnections associated with interfacing a MEMS device embedded

in a package, to a circuit, necessarily adds impedance mismatches that result in noisy or low amplitude signals.

terminal lead 104. An adhesive 118, such as a non-conductive adhesive, may be applied to the top surface of the terminal lead 104 and any intervening area of the compound 108. A cover 120 may be applied on the adhesive 118, such that the cover 120 is electrically isolated from the terminal lead 104, encloses the cavity 110, and forms a hollow package 122 for the die 112. The cover 120 is shown as being a top portion of the hollow package 122 with the terminal leads 104, the compound 108, the adhesive 118, and the die 112 entirely under the cover 120.

In certain applications the cover 120 may be applied while the unit is in an evacuated environment, or an environment charged with an inert gas. When the cover 120 is applied to the adhesive 118, the cavity 110 may become a sealed space housing either a vacuum or a gas.

Referring now to FIG. 2, therein is shown a bottom side plan view of the hollow package 122, of FIG. 1. The bottom side plan view of the hollow package 122 depicts multiple instances of the terminal lead 104 formed in an array around the die pad 106. The compound 108 has been molded around the die pad 106 and the array of the terminal lead 104. Tie bars 202 may be half etched in order to prevent unintended electrical connections between the die pad 106 and the terminal lead 104. An orientation marker 204 may be stamped or etched into the die pad 106. In some applications the orientation marker might fill with the compound 108 that surrounds the die pad 106. The orientation marker 204 may be used to indicate the location of the terminal lead 104 that is coupled to the pin one of the die 112, of FIG. 1.

Referring now to FIG. 3, therein is shown a cross-sectional view of a packaging system 300 with hollow package, in an alternative embodiment of the present invention. The cross-sectional view of the packaging system 300 depicts the terminal lead 104 partially encased by the compound 108. The adhesive 118 may be applied on the top surface of the compound 108 in order to apply the cover 120. By doing so, a hollow package 302 may be created that provides a small contact area 304 on the terminal lead 104. In certain applications this configuration may be a more manufacturable solution for designs that have dense interconnection requirements.

Referring now to FIG. 4, therein is shown a bottom plan view of the hollow package 302, of FIG. 3. The bottom plan view of the hollow package 302 depicts the die pad 106 having the orientation marker 204 and the tie bars 202. The tie bars 202 are completely encapsulated by the compound 108. The small contact area 304 remains exposed through the

compound 108 while the remainder of the terminal lead 104 is covered by the compound 108, making it unavailable for electrical connection.

What is claimed is:

1. A method of manufacture of an integrated circuit packaging system comprising:

forming terminal ~~leads~~ bent providing a vertical displacement from a bottom contact plane;

configuring a compound and the terminal leads to have a cavity by partially encapsulating the terminal leads with the~~a~~ compound including molding the compound on and between the terminal leads;

attaching an integrated circuit device, a micro-electromechanical system, a micro-mechanical system, or a combination thereof in the cavity by electrically connecting the integrated circuit device, the micro-electromechanical system, the micro-mechanical system, or a combination thereof to the terminal leads; ~~and~~

applying a non-conductive adhesive on the terminal leads; and

bonding a cover to the terminal leads with the non-conductive adhesive isolating the terminal leads from the cover ~~for~~ enclosing the cavity with the non-conductive adhesive between the terminal leads, the compound, and the cover, with the compound and the terminal leads entirely under the cover and not visible when looking at the cover.

2. The ~~system~~method as claimed in claim 1 ~~further comprising providing a vent in the cavity~~ wherein configuring the compound includes encapsulating the terminal leads to form a vent therebetween.

3. The ~~system~~method as claimed in claim 1 wherein configuring ~~the cavity by connecting the terminal leads with~~ the compound includes molding the compound around the terminal leads leaving a portion of the terminal leads exposed ~~for~~ forming a leadless package.

4. The ~~system~~method as claimed in claim 1 wherein:

bonding the cover to the terminal leads includes bonding a conductive laminate substrate to the terminal leads; and

further comprising:

forming a conductive interconnect between the terminal leads and the conductive laminate substrate above, below, or both above and below the cavity; and

mounting an additional integrated circuit device, an additional micro-electromechanical system, an additional micro-mechanical system, or a combination thereof on the conductive laminate substrate.

5. The ~~system~~method as claimed in claim 1 wherein configuring ~~the cavity includes forming the terminal leads and~~ the compound ~~for~~includes creating a recess on a bottom side thereof.

~~6. A packaging system comprising:~~

~~forming terminal leads includes the terminal leads bent for providing a vertical displacement from a bottom contact plane;~~

~~configuring a cavity by partially encapsulating the terminal leads with a compound including molding the compound on and between the terminal leads;~~

~~attaching an integrated circuit device, a micro-electromechanical system, a micro-mechanical system, or a combination thereof in the cavity by electrically connecting the integrated circuit device, the micro-electromechanical system,~~

~~the micro-mechanical system, or a combination thereof to the terminal leads; and~~

~~bonding a cover to the terminal leads for enclosing the cavity by applying an adhesive between the terminal leads, the compound, and the cover.~~

~~7.~~6. The ~~system~~method as claimed in claim ~~6~~1 ~~further comprising providing a vent in the cavity in which applying the cover includes applying the cover having~~ wherein bonding ~~the~~a the cover includes bonding ~~a~~ the cover having an acoustic orifice.

~~8.~~7. The ~~system~~method as claimed in claim ~~6~~1 wherein configuring the ~~cavity~~compound by partially encapsulating the terminal leads with the compound includes molding the compound around the terminal leads leaving a portion of the terminal leads exposed ~~for~~ forming a leadless package including having a top contact pad and the bottom contact plane in which the terminal leads ~~may be~~are plated with solder, nickel palladium, or gold.

~~9.~~8. The ~~system~~method as claimed in claim 1~~6~~ wherein:

bonding the cover to the terminal leads includes bonding a conductive laminate substrate to the terminal leads including applying the conductive laminate substrate having a bottom contact pad, a conductive link, and a top contact pad; and

further comprising:

forming a conductive interconnect between the terminal leads and the conductive laminate substrate above, below, or both above and below the cavity; and

mounting an additional integrated circuit package, an additional MEMS package, an additional micro-mechanical system, or a combination thereof on the conductive laminate substrate including mounting the additional integrated circuit package, the additional MEMS package, the additional micro-mechanical system, or the combination thereof on the top contact pad.

~~10.~~9. The ~~system~~method as claimed in claim ~~6~~1 wherein configuring the ~~cavity~~compound includes forming the terminal leads ~~and the compound to form~~having a recess on ~~the~~a bottom side thereof including positioning a mounting pad vertically displaced from the bottom contact plane.

~~11.~~10. A packaging system comprising:

terminal leads bent providing a vertical displacement from a bottom contact plane;

a compound and the terminal leads configured to have a cavity by ~~for~~ partially encapsulating the terminal leads ~~and configuring a cavity~~ with the compound, with the compound molded on and between the terminal leads;

an integrated circuit device, a micro-electromechanical system, a micro-mechanical system, or a combination thereof attached in the cavity and electrically connected to the terminal leads; ~~and~~

a non-conductive adhesive on the terminal leads; and

a cover bonded to the terminal leads with the non-conductive adhesive and electrically isolated from the terminal leads ~~for~~ enclosing the cavity by the non-conductive adhesive applied between the terminal leads, the compound, and the cover, with the compound and the terminal leads entirely under the cover and not visible when looking at the cover.

~~12.~~11. The system as claimed in claim 1~~1~~0 ~~further comprising a vent in the cavity~~ wherein the terminal leads have a vent therebetween.

~~13.~~12. The system as claimed in claim 1~~1~~0 wherein ~~the cavity configured by~~ the terminal leads are partially encapsulated with the ~~compound includes the~~ compound molded around the terminal leads with a portion of the terminal leads exposed ~~for~~ forming a leadless package.

~~14.~~13. The system as claimed in claim 1~~1~~0 wherein:

the cover bonded to the terminal leads includes a conductive laminate substrate bonded to the terminal leads;

further comprising a conductive interconnect formed between the terminal leads and the conductive laminate substrate above, below, or both above and below the cavity; and

an additional integrated circuit device, an additional micro-electromechanical system, an additional micro-mechanical system, or a combination thereof mounted on the conductive laminate substrate.

~~15.~~14. The system as claimed in claim 1~~1~~0 wherein ~~the cavity configured includes forming~~ the terminal leads and the compound ~~with~~are configured having a recess on the bottom side thereof.

~~16. The system as claimed in claim 11 wherein:~~

~~the terminal lead is bent for providing a vertical displacement from a bottom contact plane;~~

~~the compound molded on and between the terminal leads;~~

~~the integrated circuit device, the micro-electromechanical system, the micro-mechanical system, or a combination thereof electrically connected to the terminal lead; and~~

~~the cover bonded to the terminal leads for enclosing the cavity by an adhesive applied between the terminal leads, the compound, and the cover.~~

~~17.~~15. The system as claimed in claim 1~~6~~0 ~~further comprising a vent in the cavity in which the cover~~ wherein the cover includes an acoustic orifice.

~~18.~~16. The system as claimed in claim 1~~6~~0 wherein ~~the cavity configured by~~ the terminal leads partially encapsulated with the compound includes the compound molded around the terminal leads with a portion of the terminal leads left exposed forms a leadless package including having a top contact pad and the bottom contact plane in which the terminal leads ~~may be~~are plated with solder, nickel palladium, or gold.

~~19.~~17. The system as claimed in claim 1~~6~~0 wherein:

the cover bonded to the terminal leads includes a conductive laminate substrate bonded to the terminal leads, the conductive laminate substrate having a bottom contact pad, a conductive link, and a top contact pad;

further comprising a conductive interconnect formed between the terminal leads and the conductive laminate substrate above, below, or both above and below the cavity; and

an additional integrated circuit device, an additional micro-electromechanical system, an additional micro-mechanical system, or a combination thereof mounted on the conductive laminate substrate includes a package-on-package configuration.

~~20.~~18. The system as claimed in claim 1~~6~~0 wherein ~~the cavity configured includes forming~~ the terminal leads and the compound ~~with~~have a recess on ~~the~~a bottom side thereof ~~in which the recess~~ and includes a mounting pad vertically displaced from the bottom contact plane.