PRE-ENCAPSULATED LEAD FRAMES FOR MICROELECTRONIC DEVICE PACKAGES, AND ASSOCIATED METHODS

TECHNICAL FIELD

[0001] The present disclosure relates to microelectronic device packages having pre-encapsulated lead frames, and methods for manufacturing such microelectronic device packages.

BACKGROUND

[0002] Microelectronic devices generally have a die (i.e., a chip) that includes integrated circuitry with a high density of very small components. In a typical process, a large number of dies are manufactured on a single wafer using many different processes that may be repeated at various stages (e.g., implanting, doping, photolithography, chemical vapor deposition, plasma vapor deposition, plating, planarizing, and etching). The dies typically include an array of very small bond-pads electrically coupled to the integrated circuitry. The bond-pads are external electrical contacts through which the supply voltage, signals, etc., are transmitted to and from the integrated circuitry. After forming the dies, the wafer is thinned by backgrinding, and then the dies are separated from one another (i.e., singulated) by dicing the wafer. Next, the dies are "packaged" to couple the bond-pads to a larger array of electrical terminals that can be more easily coupled to the various power supply lines, signal lines, and ground lines. Conventional processes for packaging dies include electrically coupling the bond-pads on the dies to an array of leads, ball-pads, or other types of electrical terminals, and then encapsulating the dies to protect them from environmental factors (e.g., moisture, particulates, static electricity, and physical impact).

[0003] Figure 1 illustrates an existing microelectronic device package 10. The package 10 includes a microelectronic device 12 having a first end 21 and a second end 23,

a lead frame 15 supporting the microelectronic device 12, and a packaging material 24 (shown in phantom lines for clarity) encapsulating the lead frame 15 and the microelectronic device 12. The microelectronic device 12 includes bond pads 14 positioned toward the second end 23. The lead frame 15 includes first lead fingers 16 that extend under the microelectronic device 12 from the first end 21 toward the second end 23. The lead frame 15 also includes second lead fingers 18 positioned toward the second end 23 of the microelectronic device 12. The bond pads 14 are grouped into three sets of bond pads 14a-c. First and third sets of bond pads 14a, 14c are electrically connected to the second lead fingers 18 with corresponding first and third wirebonds 20a, 20c, and the second set of bond pads 14b is electrically connected to the first lead fingers 16 with second wirebonds 20b.

[0004] During assembly, the microelectronic device 12 is disposed on the first lead fingers 16. The bond pads 14a-c are connected to the first and second lead fingers 16, 18 using the wirebonds 20a-c. The first and second lead fingers 16, 18 together with the microelectronic device 12 are then disposed in a molding cavity. Liquefied packaging material 24 is injected into the molding cavity to encapsulate the microelectronic device 12 and the first and second lead fingers 16, 18.

[0005] One drawback associated with the microelectronic device package 10 is that the first lead fingers 16 and/or the second lead fingers 18 can shift during handling, transporting, assembling, or other processes. The first lead fingers 16 are especially prone to shifting because the first lead fingers 16 typically span almost the entire length L of the package 10. A small shift in neighboring first lead fingers 16 can cause the microelectronic device 12 to short circuit.

[0006] Another drawback associated with the microelectronic device package 10 is that the co-planarity of the first and second lead fingers 16, 18 cannot always be maintained during assembly. For example, the first lead fingers 16 can move out of the plane of Figure 1 before or during the molding process so as to be offset from the second lead fingers 18. Further, the weight of the microelectronic device 12 can also cause the first lead fingers 16

to tilt or depress relative to the second lead fingers 18. If the first lead fingers 16 are not located in the proper plane, the encapsulation process may not properly encapsulate the entire package 10.

[0007] One conventional approach for reducing lead finger shifting is to secure the first lead fingers 16 and/or the second lead fingers 18 with adhesive tape. As illustrated in Figure 1, adhesive tape strips 22a-c can be attached to the back sides of the first lead fingers 16 to prevent the first lead fingers 16 from moving. However, incorporating the adhesive tape strips 22a-c in the microelectronic device package 10 can reduce its reliability. For example, the adhesive tape strips 22a-c can absorb moisture, which can cause circuit failure in the microelectronic device 12. The adhesive tape strips 22a-c can also have different thermal expansion characteristics than other components of the microelectronic device package 10, which can cause cracking during operation. Accordingly, there is a need to provide more reliable and/or more robust packaging techniques.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Figure 1 is a partially exploded top view of a microelectronic device package configured in accordance with the prior art.

[0009] Figure 2 is a top view of a portion of a pre-encapsulated lead frame configured in accordance with an embodiment of the invention.

[0010] Figure 3 is a cross-sectional view of the pre-encapsulated lead frame shown in Figure 2 configured in accordance with an embodiment of the invention.

[0011] Figure 4 is a cross-sectional view of a pre-encapsulated lead frame incorporating a die paddle in accordance with another embodiment of the invention.

[0012] Figure 5 is a cross-sectional view of a pre-encapsulated lead frame having only one set of lead fingers in accordance with still another embodiment of the invention.

[0013] Figure 6 is a cross-sectional view of a pre-encapsulated lead frame incorporating an offset die paddle in accordance with yet another embodiment of the invention.

[0014] Figure 7 is a cross-sectional view of a pre-encapsulated lead frame incorporating offset lead fingers in accordance with still another embodiment of the invention.

[0015] Figure 8 is a cross-sectional view of a microelectronic device package incorporating a pre-encapsulated lead frame configured in accordance with an embodiment of the invention.

[0016] Figure 9 is a cross-sectional view of a microelectronic device package incorporating a pre-encapsulated lead frame having a die paddle in accordance with still another embodiment of the invention.

[0017] Figure 10 is a cross-sectional view of a microelectronic device package incorporating multiple microelectronic devices in a two-sided arrangement in accordance with yet another embodiment of the invention.

[0018] Figure 11 is a cross-sectional view of a microelectronic device package incorporating multiple microelectronic devices in a one-sided arrangement in accordance with another embodiment of the invention.

[0019] Figure 12 is a cross-sectional view of a microelectronic device package incorporating multiple microelectronic devices and a pre-encapsulated lead frame having a third lead finger in accordance with another embodiment of the invention.

[0020] Figure 13 is a cross-sectional view of a microelectronic device package incorporating multiple microelectronic devices and a pre-encapsulated lead frame having an offset die paddle in accordance with another embodiment of the invention.

[0021] Figure 14 is a cross-sectional view of a microelectronic device package incorporating multiple microelectronic devices and a signal distributing lead frame in accordance with another embodiment of the invention.

[0022] Figure 15 is a block diagram of a system that can include microelectronic device packages with pre-encapsulated lead frames configured in accordance with embodiments of the invention.

DETAILED DESCRIPTION

[0023] The present disclosure describes pre-encapsulated lead frames for microelectronic device packages, and associated methods. It will be appreciated that several of the details set forth below are provided to describe the following embodiments in a manner sufficient to enable a person skilled in the relevant art to make and use the disclosed embodiments. Several of the details described below, however, may not be necessary to practice certain embodiments of the invention. Additionally, the invention can include other embodiments that are within the scope of the claims but are not described in detail with respect to Figures 2-15.

[0024] Figure 2 is a top view and Figure 3 is a cross-sectional view of a portion of a pre-encapsulated lead frame 100 configured in accordance with an embodiment of the invention. Referring to Figures 2 and 3 together, the pre-encapsulated lead frame 100 can include first lead fingers 116, second lead fingers 118 spaced apart from the first lead fingers 116 in a lengthwise direction, and an encapsulating compound 120 (e.g., an epoxy molding compound) at least partially encapsulating the first and second lead fingers 116, 118. The pre-encapsulated lead frame 100 can have a generally sheet-like shape. The lead frame 100 can include a first strengthening layer 122 and a second strengthening layer 124, which are not shown in Figure 2 so as to make the underlying encapsulating compound 120 visible.

[0025] For purposes of illustration, the outermost extremities of the first and second lead fingers 116, 118 are not shown in Figures 2 and 3. These extremities are typically protected from exposure to the encapsulating compound 120 by a dam bar. After package encapsulation, the outermost extremities are typically trimmed to form external terminals, in a manner known to those of ordinary skill in the relevant art.

[0026] In the illustrated embodiment, the first lead fingers 116 can extend over at least 80% of the length L of the pre-encapsulated lead frame 100 from a first end 121 toward a second end 123 of the lead frame 100. The first lead fingers 116 can include a first connection portion 126 proximate to the first end 121, a second connection portion 128 proximate to the second end 123, and a support portion 130 between the first and second connection portions 126, 128. The support portion 130 can be configured to support one or more microelectronic devices (not shown). The first and second connection portions 126, 128 are external to the strengthening layers 122, 124 and are therefore exposed for electrical connection to a subsequently-positioned microelectronic device. A first dam bar (not shown) can join the first lead fingers 116 proximate to the first connection portions 126 and is trimmed after encapsulation to electrically isolate neighboring lead fingers. In the illustrated embodiment, the first lead fingers 116 have a zigzag profile. In other embodiments, the first lead fingers 116 can have another profile including, for example, a straight profile, a serpentine profile, or a wavy profile.

[0027] The first lead fingers 116 can be arranged side by side and spaced apart by corresponding gaps 125 (Figure 2). The encapsulating compound 120 can be disposed in the gaps 125 so as to generally fill the gaps 125 and at least partially (and in at least some cases, completely) encapsulate the first lead fingers 116. In one embodiment, the encapsulating compound 120 can have a thickness less than a thickness T (Figure 3) of the first lead fingers 116. In other embodiments, the encapsulating compound 120 in the gaps 125 can have a thickness generally equal to or greater than the thickness T of the first lead fingers 116.

[0028] The second lead fingers 118 can be spaced apart from the first lead fingers 116 in a lengthwise direction by a space 132. The encapsulating compound 120 can fill the space 132 so as to maintain the first and second lead fingers 116, 118 in a generally co-planar alignment. A second dam bar (not shown) can temporarily join the second lead fingers 118 during encapsulation, and is removed after encapsulation. In the illustrated embodiment, the second lead fingers 118 include a first group 118a and a second group

118b, each of which is positioned to align with corresponding bond sites on a corresponding microelectronic device. In other embodiments, the second lead fingers 118 can be grouped together, or can have other arrangements, depending on the configuration of the microelectronic device. The first and second lead fingers 116, 118 can be constructed from any material that has suitable strength and electrical conductivity. For example, suitable materials can include metals (e.g., copper, aluminum, zinc, etc.), metal alloys (e.g., Ni42%-58% Fe, etc.), or a combination of metals and metal alloys.

[0029] Referring now to Figure 3, the pre-encapsulated lead frame 100 can optionally include the first strengthening layer 122 and/or the second strengthening layer 124 on opposing sides of at least a section of the support portion 130 for strengthening the support portion 130. In one embodiment, the strengthening layers 122, 124 can include a layer of the encapsulating compound 120. In other embodiments, the strengthening layers 122, 124 can be formed from polyurethane, Teflon, Kevlar, or other materials suitable for strengthening the support portion 130.

[0030] The pre-encapsulated lead frame 100 can be pre-encapsulated without encapsulating a microelectronic device, using techniques such as transfer molding. For example, the first and second lead fingers 116, 118 can be secured in a desired configuration prior to molding, using pins, clips, screws, or other fasteners. The fastened first and second lead fingers 116, 118 can then be placed in a molding cavity without the microelectronic device. A liquefied encapsulating compound 120 can then be injected into the molding cavity to encapsulate the first and second lead fingers 116, 118. An operator can achieve the desired thickness for the first and/or second strengthening layers 122, 124 by selecting an appropriate mold shape, and/or a velocity and a viscosity of the liquefied encapsulating compound 120. The encapsulated first and second lead fingers 116, 118 can then be cured to form the pre-encapsulated lead frame 100.

[0031] In another example, the pre-encapsulated lead frame 100 can be pre-encapsulated using a film-assisted molding technique. A film (e.g., a piece of tape, not shown) can be taped to portions of the lead fingers 116, 118 to prevent the encapsulating

compound 120 from being deposited on the taped portions during molding. The liquefied encapsulating compound 120 can then be injected into the molding cavity to encapsulate the first and second lead fingers 116, 118 while the film remains on the lead fingers 116, 118. After molding, the film may be removed to leave the taped portions of the first and second lead fingers 116, 118 free of the encapsulating compound 120. In other examples, the pre-encapsulated lead frame 100 can be assembled using other molding techniques including, for example, compression molding, injection molding, extrusion molding, blow molding, rotational molding, thermoforming, and reaction injection molding.

[0032] The encapsulating compound 120 can generally fill the space 132 and the gaps 125 (Figure 2) and can form an at least partially rigid entity with the first and second lead fingers 116, 118. Accordingly, the encapsulating compound 120 can fix the first and second lead fingers 116, 118 relative to each other to at least reduce and in many cases eliminate lead finger shifting during handling, transporting, assembling, or other processes. The encapsulating compound 120 can also provide a strengthened support for a microelectronic device that is subsequently disposed on the lead frame 100. Further, the encapsulating compound 120 can keep the first and second lead fingers 116, 118 at least approximately co-planar by maintaining the relative positions of the first and second lead fingers 116, 118 after molding and curing.

[0033] In addition, the pre-encapsulated lead frame 100 can enable higher throughput in molding operations. Conventional techniques typically include encapsulating a matrix of 2x9 lead frames, with corresponding microelectronic devices attached, all at once using a transfer molding technique. Additional lead frames cannot be easily added to the matrix because the long lead fingers may lack the structural strength to support microelectronic devices in the larger matrix. Thus, by pre-encapsulating the first and second lead fingers 116, 118, the encapsulating compound 120 can act as a stiffener to provide additional strength to the lead frame matrix. As a result, a matrix incorporating an increased number of pre-encapsulated lead frames, along with corresponding microelectronic devices, can be

molded during a single molding operation, which can increase throughput and overall operational efficiency.

[0034] Figures 4-7 illustrate lead frames 101-104 that are generally similar to the lead frame 100 shown in Figures 2-3 in that they each include an encapsulating compound 120 as a stiffening component. However, the lead frames 101-104 can also include additional and/or different features. For example, Figure 4 illustrates a pre-encapsulated lead frame 101 that includes a die paddle (e.g., a third lead finger 117) spaced apart from but generally co-planar with the first and second lead fingers 116, 118 in a lengthwise direction. The first lead fingers 116 can extend around the die paddle 117, e.g., behind the plane of Figure 4. The die paddle 117 can provide additional access for electrical connections to a microelectronic device that is carried by the lead frame 101. A first space 134 separates the die paddle 117 from the first lead fingers 116. A second space 136 separates the die paddle 117 from the second lead fingers 118. The encapsulating compound 120 can generally fill the first and second spaces 134, 136 to fix the position of the die paddle 117 relative to the first and second lead fingers 116, 118. The lead frame 101 can optionally include one or both of the first and second strengthening layers 122, 124 positioned on the die paddle 117.

[0035] In another embodiment shown in Figure 5, a pre-encapsulated lead frame 102 has no second lead fingers 118. The second lead fingers 118 can be omitted from the pre-encapsulated lead frame 102, for example, by severing the right-hand portion of pre-encapsulated lead frame 100 of Figure 3, or by encapsulating a lead frame that does not include the second lead fingers 118 at all. The lead frame 102 can thus include the encapsulating compound 120 (located behind the plane of Figure 5) at least partially encapsulating only the first lead fingers 116. The lead frame 102 can optionally include at least one of the first and second strengthening layers 122, 124 positioned on the first lead fingers 116. The lead frame 102 can be used as an interposer for distributing signals to and/or from a microelectronic device, as described in more detail below with reference to Figure 14.

[0036] Figure 6 illustrates a pre-encapsulated lead frame 103 that can include a die paddle 119 that is offset from the first and second lead fingers 116, 118. The offset die paddle 119 can provide a support platform for a stack of multiple microelectronic devices (not shown). In the illustrated embodiment, the pre-encapsulated lead frame 103 includes only the second strengthening layer 124, but in other embodiments, the pre-encapsulated lead frame 103 can include the first strengthening layer 122 (Figure 5) in addition to and/or in lieu of the second strengthening layer 124.

[0037] Figure 7 illustrates a pre-encapsulated lead frame 104 that includes first and second lead fingers 116, 118 positioned in a first plane, and third lead fingers 115 positioned in a second plane offset from the first plane. The third lead fingers 115 can be electrically connected to the first and/or second lead fingers 116, 118 to provide a ground/power plane for a microelectronic device that is subsequently supported by the lead frame 104. In particular, the third lead fingers 115 can contain an increased volume of metal for enhanced device performance. By contrast, the two-dimensional layout of a conventional lead frame limits the volume of metal in ground/power lead fingers. To increase the volume of metal in those lead fingers, the designer must typically reduce the volume of metal in other lead fingers which can adversely affect signal speed. However, by positioning the third lead fingers 115 in the second plane, as shown in Figure 7, the volume of metal for the ground/power lead fingers can be increased without affecting the two-dimensional layout of other lead fingers in the first plane.

[0038] In further embodiments, the lead frames 100-104 can have different and/or additional components. For example, the first lead fingers 116 can be constructed from a conductive material that has greater mechanical strength than that of the second lead fingers 118. The first and second lead fingers 116, 118 can also have arrangements different than those shown in Figures 2-7.

[0039] Figures 8-13 are cross-sectional views of microelectronic device packages 200-205 that incorporate the pre-encapsulated lead frames 100-103 described above with reference to Figures 2-6. In Figures 8-13, several components of the microelectronic

device packages 200-205 are similar to the corresponding components of the lead frames 100-103 described above. As such, like reference symbols generally refer to like components in Figures 2-6.

[0040] The microelectronic device packages 200-205 can include various types of semiconductor devices, including without limitation, Dynamic Random Access Memory (DRAM) devices, Arrhythmic Logic Units (ALUs), Static Random Access Memory (SRAM) devices, or Application Specific Integrated Circuits (ASICs). The microelectronic device packages 200-205 can have any of a variety of package configurations, including without limitation, Thin Small Outline Packages (TSOP), Small Outline Integrated Circuits (SOIC), Thin Shrink Small Outline Packages (TSSOP), or Small Shrink Outline Packages (SSOP).

[0041] Figure 8 is a cross-sectional view of a microelectronic device package 200 incorporating the pre-encapsulated lead frame 100 shown in Figures 2-3, and configured in accordance with an embodiment of the invention. The microelectronic device package 200 can include a microelectronic device 210 supported by the lead frame 100, and a packaging material 220 encapsulating the microelectronic device 210 and the lead frame 100. The microelectronic device 210 can include functional components (not shown), such as memory cells, processor circuits, and interconnecting circuitry. The microelectronic device 210 can also include bond pads 224 electrically coupled to the functional components via circuitry internal to the microelectronic device. The bond pads 224 can be coupled to the first and second lead fingers 116, 118 via corresponding wirebonds 226, 228. In the illustrated embodiment, the bond pads 224 of the microelectronic device 210 are located toward one end of the microelectronic device 210. In other embodiments, the microelectronic device 210 can include other arrangements of bond pads including, for example, centered column bond pads or double-sided bond pads.

[0042] In the illustrated embodiment, the lead frame 100 includes the (optional) first and second strengthening layers 122, 124. Accordingly, an adhesive layer 211 attaches the microelectronic device 210 to the first strengthening layer 122. In another embodiment,

the adhesive layer 211 can attach the microelectronic device 210 to the second strengthening layer 122. In other embodiments, the first and second strengthening layers 122, 124 can be omitted, and the adhesive layer 211 can attach the microelectronic device 210 directly to the first lead fingers 116.

[0043] The package 200 can be encapsulated with the packaging material 220 using any of the techniques described above with reference to Figures 2-3. The packaging material 220 can include any suitable plastic, ceramic, or other protective covering. For example, the packaging material 220 can include an epoxy compound. The packaging material 220 can accordingly have a composition that is the same as or different than that of the encapsulating compound 120, depending upon the particular application. After the encapsulation process is complete, portions of the lead frame 100 projecting outside the packaging material 220 can be trimmed to form external leads for the package 200.

[0044] Because the first and second lead fingers 116, 118 are held in place with the encapsulating compound 120 (Figure 3), the lead frame 100 need not include adhesive tape. Eliminating adhesive tape for securing the first and/or second lead fingers 116, 118 can improve the reliability of the microelectronic device package 200 because the adhesive tape can absorb moisture and can have different thermal expansion characteristics than other components of the microelectronic device package 200. Further, the stabilizing effect of encapsulating compound 120 can allow the manufacturer to use first and/or second lead fingers 116, 118 having a variety of different shapes, lengths, alignments, or other features without inducing lead shift, lead tilt, or other lead configuration issues.

[0045] Figure 9 illustrates a microelectronic device package 201 incorporating an embodiment of the pre-encapsulated lead frame 101 described above with reference to Figure 4. The lead frame 101 includes a die paddle (e.g., a third lead finger) 117 that supports the microelectronic device 210. The microelectronic device 210 can include first bond pads 212 and second bond pads 214 located toward opposite ends of the microelectronic device 210. The first bond pads 212 can be electrically connected to the

first lead fingers 116 using first wirebonds 226, and the second bond pads 214 can be electrically connected to the second lead fingers 118 using second wirebonds 228.

[0046] Figure 10 illustrates a microelectronic device package 202 incorporating an embodiment of the pre-encapsulated lead frame 100 described above with reference to Figures 2-3. The package 202 can include two microelectronic devices 210 disposed on one side of the lead frame 100, and two microelectronic devices 210 disposed on the other side of the lead frame 100 using corresponding adhesive layers 211. The microelectronic devices 210 include single-sided bond pads 224 that are electrically connected to the first lead fingers 116 with first wirebonds 226, and to the second lead fingers 118 with second wirebonds 228.

[0047] Incorporating the pre-encapsulated lead frame 100 into the microelectronic device package 202 can reduce or eliminate the risk of having air pockets between adjacent first and second lead fingers 116, 118. Such air pockets may be present when conventional techniques are used to form the package 202. For example, a conventional technique for forming a package configured similarly to the package 202 shown in Figure 10 includes positioning microelectronic devices on both sides of the lead fingers before the subassembly is transferred to a molding cavity. Because the microelectronic devices cover a large portion of the gaps between adjacent lead fingers, these gaps can only be accessed through openings near the ends of the lead fingers. When a liquefied packaging material is injected into the molding cavity, the packaging material may lack sufficient pressure to fill up the gaps through these openings because other design considerations (e.g., deformation of wirebonds) can limit the amount of pressure applied. As a result, air pockets can remain between adjacent lead fingers. The air pockets can decrease the reliability of the package by interrupting heat removal. The air pockets can also cause the package to delaminate at high temperatures. However, embodiments of the pre-encapsulated lead frame 100 can reduce or eliminate the presence of air pockets because the encapsulating compound 120 can generally fill the gaps between adjacent lead fingers prior to encapsulating the entire assembly.

[0048] Figure 11 illustrates a microelectronic device package 203 incorporating an embodiment of the lead frame 100 described above with reference to Figures 2-3. The package 203 can include four microelectronic devices 210 mounted on a first side of the lead frame 100 using adhesive layers 211. The package 203 can also include a first strengthening layer 122 located on a second side of the lead frame 100 opposite the first side. The bond pads 224 of the microelectronic devices 210 include single-sided bond pads electrically connected to the first lead fingers 116 and to each other via first wirebonds 226. Second wirebonds 228 connect the bond pads 224 to the second lead fingers 118.

[0049] Figure 12 illustrates a microelectronic device package 204 incorporating an embodiment of the lead frame 101 described above with reference to Figure 4. The package 204 can include two microelectronic devices 210 disposed on one side of the lead frame 101, and two microelectronic devices 210 disposed on the other side of the lead frame 101. Spacers 213 separate neighboring microelectronic devices 210. Adhesive layers 211 attach the spacers 213 to the microelectronic devices 210 and the lead frame 101. Each microelectronic device 210 can include first bond pads 212 toward one end of the device and second bond pads 214 toward an (opposite) second end of the device. First wirebonds 226 can electrically connect the first bond pads 212 to the first lead fingers 116, and second wirebonds 228 can electrically connect the second bond pads 214 to the second lead fingers 118. Third and fourth wirebonds 227, 229 can electrically connect the first and second bond pads 212, 214 to the third lead finger 117.

[0050] Figure 13 illustrates a microelectronic device package 205 incorporating an embodiment of the lead frame 103 described above with reference to Figure 6. The package 205 can include four microelectronic devices 210 carried by a recessed portion of the lead frame 103. Spacers 213 separate adjacent microelectronic devices 210, and adhesive layers 211 attach the stacked microelectronic devices 210 to each other and to the lead frame 103. The first wirebonds 226 can electrically connect the first bond pads 212 to

the first lead fingers 116, and the second wirebonds 228 can electrically connect the second bond pads 214 to the second lead fingers 118.

[0051] Figure 14 illustrates a microelectronic device package 206 incorporating an embodiment of the lead frame 102 described above with reference to Figure 5. The package 206 can include a stack of four microelectronic devices 210 attached to each other with adhesive layers (not shown). The stack of microelectronic devices 210 can be carried by a die paddle 217, or directly by the lead frame 102. The lead frame 102 is disposed on the stack and can facilitate signal distribution to and/or from the microelectronic devices 210, as is described in greater detail later. The first wirebonds 226 can electrically connect the first connection portion 126 of the lead frame 102 to the first lead fingers 216. The second wirebonds 228 can electrically connect the die bond pads 224 to the second lead fingers 218. The third wirebonds 227 can electrically connect the microelectronic devices 210 to the second connection portion 128 of the lead frame 102.

[0052] In operation, the lead frame 102 can distribute electrical signals and/or power among the microelectronic devices 210 and external devices (not shown). For example, electrical signals can be transmitted from one of the microelectronic devices 210 to the second connection portion 128 of the lead frame 102. The lead frame 102 can then distribute the electrical signals to the first connection portion 126. The first wirebonds 226 can then transmit the electrical signals from the first connection portion 126 to the first lead fingers 216 to be received by external devices.

[0053] An embodiment of the microelectronic device package 206 described above can be manufactured without silicon interposers. In particular, the lead frame 102 can be substituted for a silicon interposer. This is unlike at least some conventional arrangements, which use silicon interposers for distributing electrical signals from the die bond pads 224 to the first lead fingers 216. Such silicon interposers can be complex and costly to fabricate. Accordingly, using the pre-encapsulated lead frame 102 can reduce the cost of distributing electrical signals in the microelectronic device package 206.

[0054] Individual microelectronic device packages 200-205 may be incorporated into any of a myriad of larger and/or more complex systems 180, a representative one of which is shown schematically in Figure 15. The system 180 can include a processor 181, a memory 182 (e.g., SRAM, DRAM, Flash, and/or other memory device), input/output devices 183, and/or other subsystems or components 184. Individual microelectronic device packages 200-205 may be included in any of the components shown in Figure 15. The resulting system 180 can perform any of a wide variety of computing, processing, storage, sensor and/or other functions. Accordingly, representative systems 180 include, without limitation, computers and/or other data processors, for example, desktop computers, laptop computers, Internet appliances, hand-held devices (e.g., palm-top computers, wearable computers, cellular or mobile phones, personal digital assistants), multi-processor systems, processor-based or programmable consumer electronics, network computers, and mini computers. Other representative systems 180 include cameras, light or other radiation sensors, servers and associated server subsystems, display devices, and/or memory devices. Components of the system 180 may be housed in a single unit or distributed over multiple, interconnected units, e.g., through a communications network. Components can accordingly include local and/or remote memory storage devices, and any of a wide variety of computer-readable media.

[0055] From the foregoing, it will be appreciated that specific embodiments of the invention have been described herein for purposes of illustration, but that various modifications may be made without deviating from the invention. For example, the microelectronic device packages 200-206 shown in Figures 8-14 can incorporate any of the pre-encapsulated lead frames 100-104 shown in Figures 2-7. The microelectronic devices may be stacked and/or arranged in manners other than those shown in the Figures. Features of various embodiments described above may be combined or eliminated in other embodiments. For example, individual lead finger configurations shown in Figures 2-7 may be combined with each other. In addition, the microelectronic device packages may include components in addition to and/or other than those shown in the Figures. Accordingly, the invention is not limited except as by the appended claims.

CLAIMS

I/We claim:

[c1] 1. A lead frame assembly, comprising:

a set of multiple lead fingers arranged side by side with neighboring lead fingers spaced apart from each other by a corresponding gap; and

an encapsulating compound at least partially encapsulating the set of lead fingers without encapsulating a microelectronic device, wherein the encapsulating compound generally fills the gaps between neighboring lead fingers.

[c2] 2. The lead frame assembly of claim 1 wherein the encapsulating compound completely fills the plurality of gaps between neighboring lead fingers.

[c3] 3. The lead frame assembly of claim 1 wherein the set of lead fingers is a first set of lead fingers, and wherein the lead frame assembly further comprises a second set of lead fingers spaced apart from the first set of lead fingers in a lengthwise direction by a space, and wherein the encapsulating compound generally fills the space between the first and second sets of lead fingers.

[c4] 4. The lead frame assembly of claim 3 wherein the first and second sets of lead fingers and the encapsulating compound form a sheet-like shape.

[c5] 5. The lead frame assembly of claim 3, further comprising a die paddle spaced apart from the first and second sets of lead fingers in the lengthwise direction, the die paddle and the first and second sets of lead fingers being generally co-planar.

[c6] 6. The lead frame assembly of claim 3, further comprising a die paddle spaced apart from the first and second sets of lead fingers in the lengthwise direction, the die paddle being offset from a plane that includes the first and second sets of lead fingers.

[c7] 7. The lead frame assembly of claim 3 wherein the first and second sets of lead fingers are located in a first plane, and wherein the lead frame assembly further comprises a third set of lead fingers located in a second plane offset from the first plane, the third set of lead fingers being encapsulated by the encapsulating compound.

[c8] 8. The lead frame assembly of claim 1, further comprising a layer of encapsulating compound carried by at least a portion of the lead fingers outside the gaps.

[c9] 9. The lead frame assembly of claim 1 wherein the encapsulating compound is a first encapsulating compound, and wherein the lead frame assembly further comprises a layer of a second encapsulating compound carried by at least a portion of the lead fingers outside the gaps, the second encapsulating compound having a composition different than a composition of the first encapsulating compound.

[c10] 10. The lead frame assembly of claim 1 wherein the encapsulating compound in the gaps has a thickness no greater than a thickness of the lead fingers.

[c11] 11. The lead frame assembly of claim 1 wherein the encapsulating compound in the gaps has a thickness generally equal to a thickness of the lead fingers.

[c12] 12. A microelectronic device package, comprising:

a pre-encapsulated lead frame including a first set of lead fingers, a second set of lead fingers spaced apart from the first set of lead fingers, and an encapsulating compound at least partially encapsulating the first and second sets of lead fingers;

a microelectronic device carried by the pre-encapsulated lead frame; and

a packaging material encapsulating the pre-encapsulated lead frame and the microelectronic device in a single package.

[c13] 13. The microelectronic device package of claim 12 wherein the pre-encapsulated lead frame further includes a layer of encapsulating compound between the first set of lead fingers and the microelectronic device.

[c14] 14. The microelectronic device package of claim 12 wherein the encapsulating compound is a first encapsulating compound, and wherein the pre-encapsulated lead frame further includes a layer of a second encapsulating compound between the first set of lead fingers and the microelectronic device, the second encapsulating compound having a composition different than a composition of the first encapsulating compound.

[c15] 15. The microelectronic device package of claim 13 wherein the layer of encapsulating compound is a first layer located on a first side of the first set of lead fingers, and wherein the pre-encapsulated lead frame further includes a second layer of encapsulating compound located on a second side of the first set of lead fingers opposite the first side.

[c16] 16. The microelectronic device package of claim 12 wherein the pre-encapsulated lead frame further includes a die paddle spaced apart from the first and second sets of lead fingers, and wherein the microelectronic device is carried by the die paddle.

[c17] 17. The microelectronic device package of claim 12 wherein the encapsulating compound has a different composition than a composition of the packaging material.

[c18] 18. The microelectronic device package of claim 12 wherein the microelectronic device is a first microelectronic device disposed on a first surface of the pre-encapsulated lead frame, and wherein the microelectronic device package further comprises a second microelectronic device disposed on a second surface of the pre-encapsulated lead frame, the second surface being opposite the first surface.

[c19] 19. The microelectronic device package of claim 18 wherein individual lead fingers of the first set of lead fingers are arranged side by side and spaced apart from each other by a plurality of gaps, and wherein the encapsulating compound generally fills the gaps, and wherein the microelectronic device package is generally free of air pockets in the gaps.

[c20] 20. The microelectronic device package of claim 12 wherein the pre-encapsulated lead frame has a thickness no greater than a thickness of the first set of lead fingers.

[c21] 21. The microelectronic device package of claim 12 wherein the pre-encapsulated lead frame has a thickness generally equal to a thickness of the first set of lead fingers.

[c22] 22. A computing system comprising at least one of a processor, a memory, and an input/output device, wherein the computing system includes the microelectronic device package according to claim 12.

[c23] 23. A microelectronic device package, comprising:

a first set of lead fingers;

a second set of lead fingers spaced apart from the first set of lead fingers;

a lead frame between the first and second sets of lead fingers, the lead frame having a third set of lead fingers located between the first set of lead

fingers and the second set of lead fingers, the lead frame further having an encapsulating compound at least partially encapsulating the third set of lead fingers;

a microelectronic device having bond pads proximate to one edge of the lead frame;

a first set of wirebonds electrically connecting the first set of lead fingers and the third set of lead fingers;

a second set of wirebonds electrically connecting the bond pads and the third set of lead fingers; and

a packaging material encapsulating the lead frame and the microelectronic device into a single package.

[c24] 24. The microelectronic device package of claim 23 wherein the packaging material completely encapsulates the third set of lead fingers and only partially encapsulates the first and second sets of lead fingers.

[c25] 25. A method for assembling a microelectronic device package, comprising:

encapsulating a set of lead fingers with an encapsulating compound, forming a pre-encapsulated lead frame without encapsulating a microelectronic device;

supporting the microelectronic device with the pre-encapsulated lead frame;

electrically coupling the microelectronic device to the lead fingers of the pre-encapsulated lead frame while the pre-encapsulated lead frame supports the microelectronic device; and

encapsulating the microelectronic device and the pre-encapsulated lead frame in a package.

[c26] 26. The method of claim 25 wherein neighboring lead fingers are spaced apart from each other by a corresponding gap, and wherein the method further comprises completely filling the gaps with the encapsulating compound.

[c27] 27. The method of claim 25 wherein encapsulating a set of lead fingers includes forming a pre-encapsulated lead frame having a thickness no greater than a thickness of the lead fingers.

[c28] 28. The method of claim 25 wherein encapsulating a set of lead fingers includes forming a pre-encapsulated lead frame having a thickness generally equal to a thickness of the lead fingers.

[c29] 29. The method of claim 25 wherein encapsulating a set of lead fingers further includes disposing a layer of the encapsulating compound on the lead fingers external to gaps between neighboring lead fingers.

[c30] 30. The method of claim 25 wherein the encapsulating compound is a first encapsulating compound, and wherein encapsulating a set of lead fingers further includes disposing a layer of a second encapsulating compound on the lead fingers, the second encapsulating compound having a composition different than a composition of the first encapsulating compound.

[c31] 31. The method of claim 25 wherein the set of lead fingers is a first set of lead fingers, and wherein encapsulating a set of lead fingers further includes encapsulating a second set of lead fingers with the encapsulating compound.

[c32] 32. The method of claim 31 wherein the second set of lead fingers is spaced apart in a lengthwise direction from the first set by a space, and wherein

encapsulating a set of lead fingers further includes completely filling the space with the encapsulating compound.

[c33] 33. The method of claim 25, further comprising at least restricting movement of the lead fingers from a common plane.

[c34] 34. The method of claim 25 wherein the microelectronic device is a first microelectronic device, and wherein the method further comprises:

attaching a second microelectronic device to the first microelectronic device; and

electrically coupling the second microelectronic device to the lead fingers of the pre-encapsulated lead frame.

[c35] 35. A method for assembling a lead frame, comprising:

disposing a set of lead fingers into a molding cavity; and

encapsulating the set of lead fingers with an encapsulating compound in the molding cavity, without encapsulating a microelectronic device.

[c36] 36. The method of claim 35, further comprising fastening the set of lead fingers in a desired arrangement with at least one removable fastener prior to encapsulating the lead fingers.

[c37] 37. The method of claim 35 wherein encapsulating the set of lead fingers includes applying a liquefied encapsulating compound to the set of lead fingers in the molding cavity.

[c38] 38. The method of claim 35 wherein the set of lead fingers is a first set of lead fingers, and wherein the method further comprises positioning a second set of lead fingers in the molding cavity, the second set of lead fingers being spaced apart from the

first set of lead fingers in a lengthwise direction, with the first and second sets of lead fingers positioned in a common plane.

[c39] 39. The method of claim 38, further comprising:

encapsulating the first and second sets of lead fingers together; and

at least restricting movement of the first and second sets of lead fingers from the common plane.

[c40] 40. The method of claim 38 wherein the first and second sets of lead fingers are located in a first plane, and wherein the method further includes positioning a third set of lead fingers in the molding cavity, the third set of lead fingers being located on a second plane offset from the first plane.