ELECTRONIC MODULE HAVING CANOPY-TYPE CARRIERS

FIELD OF THE INVENTION

This invention relates to the production of multi-chip electronic modules, and more particularly to a method and apparatus for attaching multiple integrated circuit packages to printed circuit boards. It also relates to high-density memory modules having three-dimensional arrangements of integrated circuit packages.

BACKGROUND OF THE INVENTION

Demand for semiconductor memory is highly elastic. On one hand, when such memory is relatively inexpensive compared to the overall cost of a computer system, an almost unsatiable demand results, with computer manufacturers tending to install an amount of main memory in each system that greatly exceeds the amount required for average program use. On the other hand, when it is costly, manufacturers typically install an amount in each system that only marginally fulfills the requirement of the average program. Although the sales prices of computers may, thus, be maintained at low levels, the end user may soon find that he must upgrade his computer's main memory.

The ever increasing demand for large random access computer memories, and the growing demand for increasingly compact computers, coupled with an incentive on the part of the semiconductor manufacturers to reduce the cost per bit, has lead to not only a quadrupling of circuit density approximately every three years, but to increasingly efficient techniques for packaging and mounting the circuit chips. Up until the late 1980's, semiconductor memory chips were usually packaged as dual in-line pin packages (DIPPs). The pins of these DIPP packages were generally soldered directly within through-holes in a main circuit board (e.g., the motherboard), or they

were inserted in sockets which were, in turn, soldered within through-holes in the main circuit board. With the advent of surface mount technology, conventional plated through-holes on printed circuit boards have been replaced with conductive mounting pads. Small Outline J-lead (SOJ) packages have lead to Thin Small Outline Packages (TSOPs). Because the pitch or spacing between centers of

adjacent surface mount pins is significantly less than the conventional 0.10-inch spacing for conventional through-hole components, surface mount chips tend to be considerably smaller than corresponding conventional chips, thus taking up less space on a printed circuit board. Additionally, as through holes are no longer needed, surface mount technology lends itself to the mounting of components on both sides of a printed circuit board. Memory modules utilizing surface-mount packages on both sides have become the standard. Both the earlier single in-line memory modules (SIMMs) and the currently used dual in-line memory modules (DIMMs) are inserted into sockets on the motherboard.

Packaging density may be increased rather dramatically by fabricating modules in which a plurality of integrated circuit (IC) chips, such as memory chips, are stacked in a three dimensional arrangement. As a general rule, the three-dimensional stacking of chips requires complex, non-standard packaging methods.

One example of a vertical stack of IC chips is provided by U.S. Pat. No. 4,956,694 to Floyd Eide, titled INTEGRATED CIRCUIT CHIP STACKING. A plurality of integrated circuits are packaged within package carriers and stacked, one on top of the other, on a printed circuit board. Except for the chip select terminal, all other like terminals on the chips are connected in parallel.

Another example of chip stacking is given in U.S. Pat. No. 5,128,831 to Fox, et al. titled HIGH-DENSITY ELECTRONIC PACKAGE COMPRISING STACKED SUB-MODULES WHICH ARE ELECTRICALLY INTERCONNECTED BY SOLDER-FILLED VIAS. The package is assembled from individually testable sub-modules, each of which has a single chip bonded thereto. The sub-modules are interleaved with frame-like spacers. Both the sub-modules and the spacers have alignable vias which provide interconnection between the various sub-modules.

U.S. Pat. No. 5,313,096, also issued to Floyd Eide and titled IC CHIP PACKAGE HAVING CHIP ATTACHED TO AND WIRE BONDED WITHIN AN OVERLYING SUBSTRATE, is another example. Such a package includes a chip having an upper active surface bonded to the lower surface of a lower substrate layer having conductive traces on its upper surface which terminate in conductive pads on its periphery. Connection between terminals on the active surface and the traces is made with wire bonds through apertures within the lower substrate layer.

An upper substrate layer, which is bonded to the lower substrate layer, has apertures which coincide with those of the lower substrate layer and provide space in which the wire bonding may occur. After wire bonding has occurred, the apertures are filled with epoxy to form an individually testable sub-module. Multiple sub-modules can be stacked and interconnected with metal strips attached to their edges.

A final example of a stacked-chip module is disclosed in U.S. Pat. No. 5,869,353 to A. U. Levy, et al. titled MODULAR PANEL STACKING PROCESS. A plurality of panels are fabricated having apertures therein, an array of chip-mounting pads at the bottom of the apertures, and interfacing conductive pads. Both the chip-mounting pads and the interfacing conductive pads are coated with solder paste. Plastic-encapsulated surface-mount IC chips are positioned on the paste-covered mounting pads, multiple panels are stacked in a layered arrangement and the stack is heated to solder the chip leads to the mounting pads and the interfacing pads of adjacent panels together. Individual chip package stacks are then separated from the panel stack by a cutting and cleaving operation.

As can be seen by the foregoing examples, increased chip density is achieved through the use of complicated packaging and stacking arrangements, which must necessarily be reflected in a higher cost per bit of storage.

SUMMARY OF THE INVENTION

The present invention provides for increased circuit density on printed circuit boards. The invention is particularly useful for increasing the density of memory chips on memory modules used for computer systems. The invention includes a package carrier that is designed to mount on a printed circuit board (PCB) on top of a first integrated circuit (IC) package that is also mounted on the PCB. The carrier has an upper major surface having a pad array on which a second IC package is mountable. When mounted on top of the first IC package, the carrier may be thought of as a canopy or platform, on top of which the second IC package is mounted. The carrier has a plurality of leads by means of which the carrier is surface mounted to the PCB. Each carrier lead is also electrically connected to a single pad of the pad array on the upper surface. The invention also includes a multi-chip module assembled using at least one PCB, at least one package carrier and at least two IC

packages associated with each carrier (one mounted on the carrier and the other mounted beneath the carrier on the PCB). For multi-chip modules where the IC package beneath the carrier shares all or most connections in common with the IC package mounted thereupon, a single lead of the carrier and a single lead of the package beneath the carrier may share a mounting/connection pad on the PCB. When separate connections must be made by similarly positioned leads on the carrier and the package beneath the carrier, the corresponding pad on the PCB may be split so that each lead has a unique connection. Alternatively, a pad beneath an electrically unused lead on the lower package may be used for a unique signal for the upper package by rerouting the signal from the standard package lead to carrier lead which corresponds to the unused lead.

A first embodiment of the carrier includes a body having a first pad array, arranged as two parallel linear rows of pads, and adhered to an upper major surface thereof. The leads of an IC package may be conductively bonded to the pads of the first pad array. The body also has a second pad array, arranged as two parallel linear rows of pads positioned along the longitudinal edges, and adhered to the lower major surface thereof. Pads of the first and second arrays are interconnected with conductively-plated vias, or through holes. The carrier leads are conductively bonded to the pads of the second array. The carrier incorporates a heat sink feature. The end leads on a first side of the carrier are both power leads. These two power leads are interconnected by a first laminar sheet which is continuous with and extends between those two leads, and which may extend the entire length of the carrier. An end portion of the first laminar sheet may be exposed at each end of the carrier to facilitate the transfer of heat to the ambient air. The end leads on a second side of the carrier are both ground leads. These two ground leads are interconnected by a second laminar sheet which is continuous with and extends between these two leads, and which may extend the entire length of the carrier. An end portion of the second laminar sheet may be exposed at each end of the carrier to facilitate the transfer of heat to the ambient air. Each laminar sheet is spaced apart from the intervening leads of the same row. The first and second laminar sheets are spaced apart from one another along the center of the carrier. Each IC package includes a dielectric body, an IC chip embedded within the body, and a

plurality of leads, an end of each of which is also embedded within the body and electrically conductively coupled to a connection terminal on the IC chip. For a preferred embodiment of the multi-chip module, an upper surface of the body of the lower IC package is either in intimate contact with both laminar sheets, or thermally coupled thereto via a thermally-conductive compound, or in close proximity thereto to facilitate heat transfer from the package body to the laminar sheets.

A second embodiment of the carrier includes modified leads, each of which functions as a heat sink. A center portion of each lead is bonded to a pad of the second pad array on lower surface of the carrier body. An outer portion of each lead is shaped for surface mounting to a mounting/connection pad on a PCB. An inner portion of each lead extends toward the center of the body. For a preferred embodiment of the multi-chip module, an upper surface of the body of the lower IC package is either in intimate contact with the inner portion of each lead, or thermally coupled thereto via a thermally-conductive compound, or in close proximity thereto to facilitate heat transfer from the package body to the leads.

A fourth embodiment of the carrier includes only a set of leads. Originally attached to a lead frame for proper positioning during the manufacturing process, the upper package is electrically and physically attached to the set of leads by, for example, a solder reflow process. Following solder reflow, the chip/leadframe assembly is subjected to a trim and form process to create a carrier-mounted package having leads which extend both outwardly and downwardly from the package, thereby creating a space beneath which the first package may be mounted on the PCB.

A fifth embodiment of the carrier is adapted for mounting of one or more ball-grid array type IC packages. Modules may be constructed having one or more ball-grid-array type packages mounted on the PCB beneath the carrier, on which one or more other ball-grid-array type packages are mounted.

DESCRIPTION OF THE DRAWINGS

Figure 1 is an isometric view of a first embodiment package carrier showing the top thereof;

Figure 2 is an isometric view of the first embodiment package carrier body,

showing the underside thereof;

Figure 3 is an isometric view of the carrier leads of the package carrier of Figure 1;

Figure 4 is an isometric view of the first and second heat sink sheets, which are connected to the ground leads and the power leads, respectively;

Figure 5 is an isometric view of an exploded portion first embodiment electronic module shown in relation to the first and second integrated circuit packages;

Figure 6 is an isometric view of an assembled portion of the first embodiment electronic module;

Figure 7 is an isometric view of a second embodiment package carrier;

Figure 8 is an isometric view of the second embodiment package carrier body, showing the underside thereof;

Figure 9 is an isometric view of the carrier leads of the package carrier of Figure 7;

Figure 10 is a top plan view of a carrier body of either the first or second embodiment package carrier;

Figure 11 is an isometric view of an exploded portion second embodiment electronic module;

Figure 12 is an isometric view of an assembled portion of the second embodiment electronic module;

Figure 13 is an isometric view of a leadframe segment used in the manufacture of a bodyless canopy carrier;

Figure 14 is an exploded isometric view of the leadframe segment of Figure 13 and a dual-gullwing IC package for mounting thereon;

Figure 15 is an isometric view of the assembled leadframe segment and IC package of Figure 14;

Figure 16 is an isometric view of the assembled leadframe segment and IC package of Figure 15 following a trim and form operation, but prior to the attachment of an adhesive film patch on the lower surfaces of the leads;

Figure 17 is an isometric view of the fully-assembled leads, IC package and film patch of Figure 16;

Figure 18 is an exploded isometric view of the assembly of Figure 17 and an additional IC package, both ready for mounting on a portion of a circuit board;

Figure 19 is an assembled view of the elements shown in Figure 18;

Figure 20 is an isometric view of a DIMM module comprising multiple Fig. 19 assemblies;

Figure 21 is an isometric view of a representative ball-grid-array IC package;

Figure 22 is an exploded isometric view of four ball-grid-array IC packages and a dual-package carrier designed to receive ball-grid-array IC packages, ready for mounting on a circuit board;

Figure 23 is an assembled view of the elements shown in Figure 22;

Figure 24 is an isometric view of an assembled DIMM module comprising multiple Figure 23 assemblies; and

Figure 25 is an isometric view of a single-package carrier designed to receive ball-grid-array IC packages and two such packages mounted on a portion of a printed circuit board.

DETAILED DESCRIPTION OF THE INVENTION

As will be evident from the attached drawing figures, the present invention permits the manufacture of electronic modules having increased circuit density. The invention may be used for a variety of applications. One very obvious usage is in the manufacture of memory modules. As memory modules typically incorporate a printed circuit board having rigidly prescribed dimensions, more efficient use of the board real estate will result in a module having greater total memory capacity. The invention may also be utilized to closely couple related, but dissimilar, IC packages. For example, it may be desirable to mount an IC package containing high-speed cache memory on top of an IC package containing a microprocessor chip. The various embodiments of the improved electronic module will now be described in detail with reference to the accompanying drawings.

Referring now to Figures 1 and 2, a first embodiment package carrier 100 has a dielectric body 101 having upper and lower parallel major planar surfaces 102U and 102L, respectively. For a preferred embodiment of the invention, the body is

made from the fiberglass-reinforced plastic material commonly used to manufacture printed circuit boards. The dielectric body 101 also has a first mounting pad array 103 affixed to said upper major planar surface 102U. The mounting pads 104 of the array 103 are individually shaped and collectively arrayed to receive the leads of a first integrated circuit package (not shown in this drawing figure). The dielectric body 101 also includes a second mounting pad array 105 affixed to said lower major planar surface 102L. Each pad 106 of the second array 105 is coupled to a pad 104 of said first array 103 by means of an internally plated aperture 10 which extends between the upper major planar surface 102U and the lower major surface 102L. The package carrier 100 also includes a set of carrier leads 108, each of which is conductively bonded to a pad 106 of the second mounting pad array 105. The individual leads 108A of the carrier lead set 108 are spaced and configured for surface mounting on a printed circuit board (not shown in this drawing figure). It will be noted that the body 101 has a cutout 109 at each end thereof.

It will also be noted that for this embodiment of a carrier, the spacing between the two rows of pads 104 of the first array 103 is narrower than the spacing between the two rows of pads 106 of the second array. The reason for this difference in spacing is that the package carrier 100 may be thought of as a canopy or platform which overlies and bridges a second integrated circuit package mounted on the printed circuit board. Thus, carrier leads 108 must be wider spaced so that they mount outside of the leads of the package so covered. The package carrier 100 also includes a pair of capacitor mounting pads 110 at each end thereof. The pads of each pair are sized and spaced to receive a surface mount decoupling capacitor 111.

Referring now to Figure 3, the carrier lead set 108 of the first embodiment package carrier 100 includes a plurality of articulated leads 301, each of which is individually attached to a pad 106 of the second mounting pad array 105. The outer portion of each of the leads 301 is essentially C-shaped. The carrier lead set 108 also includes a trio of power leads 302, which are interconnected via a first laminar sheet 303, which also serves as a heat sink layer. Also included in the carrier lead set 108 is a trio of ground leads 304, which are interconnected via a second laminar sheet 305, which also serves as a heat sink layer. Both the first and second laminar

sheets 303 and 305, respectively, incorporate a pair of extension tabs 306, which enhance heat dissipation from the laminar sheets. The cutouts 109 expose portions of the first and second laminar sheets 303 and 305, thereby aiding in heat dissipation to the ambient air.

Figure 4 shows the carrier lead set 108 minus all articulated leads 301. The three power leads 302 and associated interconnected heat sink layer 303 are on the left, while the three ground leads 304 and associated interconnected heat sink layer 305 are on the right. The extension tabs 306 are also readily visible.

Referring now to Figure 5, a first integrated circuit package 501 having a plurality of leads 502 is shown aligned for surface mounting to the first mounting pad array 103 on the upper major planar surface 102U of the first embodiment package carrier 100. A printed circuit board 503 includes a third mounting pad array 504 having individual mounting pads 505 arranged in two parallel rows 506L and 506R. A second integrated circuit package 507 having a plurality of leads 508 is shown aligned for surface mounting to the third mounting pad array 504. The package carrier 100 is also aligned for surface mounting to the third mounting pad array 504. The package carrier is designed so that its two rows of leads [109] 108L and 108R constituting its carrier lead set 108 are spaced wider than the rows of leads 508 on the second integrated circuit package 507. Such an arrangement permits one carrier lead 109 and one second package lead 508 to share a common mounting pad 505 on the printed circuit board 503. Where the signals and/or power inputs are common, the pad 505 need not be split. However, where the signals are different (e.g., chip select signals), then the pad 505 may be split so that a different signal or power requirement may be delivered to the proper lead. Pad 505S is such a split pad. If both the first and second packages 501 and 507, respectively, are memory chips and the first package 501 is surface mounted to the carrier 100 and the carrier 100 and the second package are surface mounted to the printed circuit board 503, then each chip may be individually selected by sending a signal to the appropriate half of pad 505S. An alternative method of routing chip select signals to two identical chips involves utilizing a pad for an unused lead (of which there are typically several on each package) for one of the chip select signals and then rerouting the signal within the carrier body 101 to the pad where the chip select lead will be bonded. It

will be noted that the printed circuit board includes a pair of capacitor mounting pads 509 at opposite corners of the third mounting pad array 504. The pads of each pair are sized and spaced to receive a surface mount decoupling capacitor 111. Additionally, more than two capacitors for each chip may be employed. It should be evident that for a pair of identical memory chips, all connections, other than the chip select input, will be vertically superimposed. In such a case, the internally-plated apertures 107 will be used to interconnect a pad 104 of the first mounting pad array 103 with a vertically-aligned pad 106 of the second mounting pad array 105. When dissimilar first and second integrated circuit packages are employed, rerouting of the connections may be necessary. This may be accomplished in the same manner as used for printed circuit board design. Thus, between the first 103 and second 105 mounting pad arrays which are respectively located on the upper 102U and lower 102L surfaces of the carrier body 101, one or more intervening layers of traces are embedded within the dielectric material of the body 101. The intervening layers may also be interconnected with internally plated apertures. This technique is so common in printed circuit board manufacturing that it hardly requires discussion in this document.

Referring now to the assembled first embodiment electronic module 600 of Figure 6, a second integrated circuit package 507 is surface mounted to a third mounting pad array 504 on a printed circuit board 503, a first embodiment package carrier 100 is also surface mounted to the third mounting pad array 504, and a first integrated circuit package 501 is surface mounted to the first mounting pad array 103 of the package carrier 100. The assembly also includes four decoupling capacitors 111 which are surface mounted to capacitor mounting pads 110 and 509.

Figures 7, 8 and 9 show a second embodiment package carrier 700 in both assembled form (Figure 7) and component form (Figures 8 and 9). The principal difference between the first embodiment carrier 100 and the second embodiment carrier 700 is the shape of the leads 701. It will be noted that each lead has an elongated portion which functions as a heat sink. There are no laminar sheets coupled to either the power and ground leads, as is the case for the first embodiment carrier 100. Figure 8 shows the under side of the dielectric carrier body 101 which, in this case, is identical to that of the first embodiment carrier 100.

Referring now to Figure 10, a top view of the body of either the first or second chip carrier shows one configuration for the routing of traces for the decoupling capacitor mounting pads 110 and 509 (Figs 5 and 6). Trace 1001 couples pad 110A to a power mounting pad 104P of the first mounting pad array 103, while trace 1002 couples pad 110B to a ground mounting pad 104G of the first mounting pad array 103. Likewise, trace 1003 couples pad 509C to a ground mounting pad 104G of the first mounting pad array 103, while trace 1004 couples pad 509D to a power mounting pad 104P of the first mounting pad array 103.

Referring now to the exploded view of Figure 11, a first integrated circuit package 501 having a plurality of leads 502 is shown aligned for surface mounting to the first mounting pad array 103 on the upper major planar surface 102U of the second embodiment package carrier 700. A printed circuit board 503 includes a third mounting pad array 504 having individual mounting pads 505 arranged in two parallel rows 506L and 506R. A second integrated circuit package 507 having a plurality of leads 508 is shown aligned for surface mounting to the third mounting pad array 504. The second embodiment package carrier 700 is also aligned for surface mounting to the third mounting pad array.

Referring now to the assembled second embodiment electronic module 1200 of Figure 12, a second integrated circuit package 507 is surface mounted to a third mounting pad array 504 on a printed circuit board 503, a second embodiment package carrier 700 is also surface mounted to the third mounting pad array 504, and a first integrated circuit package 501 is surface mounted to the first mounting pad array 103 of the package carrier 100. The assembly also includes four decoupling capacitors 111 which are surface mounted to capacitor mounting pads 110 and 509.

Referring now to Figure 13, a leadframe segment 1300 used for the manufacture of a bodyless canopy carrier includes a pair of frame rails 131, a pair of rail-linking members 1302, and a set of leads 1303L and [133R] 1303R arranged in right and left groups. The leads of each group are connected to one another and to the rail-linking members 1302 by connector links [134] 1304. It should be understood that an entire leadframe strip may include many such leadframe segments 1300.

Referring now to Figure 14, an IC package 501 having dual rows of gullwing leads 502 is positioned above the leadframe segment 1300. The dashed lines in the figure indicate the future mounting position of the package 501 on the leadframe segment 1300.

Referring now to Figure 15, the IC package 501 has been attached to the leadframe segment 1300 via, for example, a solder reflow step. It will be noted that the leads 502 of package 501 are positioned inside the connector links 1304.

Referring now to Figure 16, the assembly of Figure 15 has been subjected to a trim and form step, during which the connector links 1304 which interconnected the leads and the rail-linking members 1302 have been punched out, thereby singulating each IC package 501 and its attached leads 1303. The leads 1303 have been formed during the step to create, in effect, a bodyless canopy type carrier. An adhesive film strip 1601, which may be a piece of thermally-conductive, electrically-insulative, thermo-setting tape, is ready for attachment to the underside of the assembly. Specifically, the film strip 1601 will be attached to the lower surfaces of the leads 1303. The presence of this film strip 1601 makes rework of the assembly feasible, even after trim and form/singulation step is complete.

Referring now to Figure 17, the adhesive film patch 1601 has been attached to the lower surface of the leads 1303. An IC package assembly 1701, consisting of the IC package 501, the attached canopy, or carrier, leads 1303 and the attached film strip 1601, is now ready for mounting on a printed circuit board.

Referring now to Figure 18, the IC package assembly 1701 of Figure 17 is shown positioned over another IC package 507, which is positioned over a portion of a printed circuit board 503. As is the case with the embodiment shown in Figure 5, the leads of both the IC package assembly 507 and the IC package 507 will be surface mounted on

to the pads of the mounting pad array 504, which is arranged in two parallel rows 506L and 506R. Decoupling capacitors111 are also shown positioned for mounting on the printed circuit board 503.

Referring now to the assembled third embodiment electronic module 1900 of Figure 19, the individual elements shown in Figure 18 have been assembled on the printed circuit board portion 503. Figure 20 shows eight Figure 18 assemblies

incorporated in a single DIMM module 2001. DIMM modules are commonly used as memory expansion boards for personal computers.

Referring now to Figure 21, a canopy type package carrier may also incorporate ball-grid-array type IC packages. Each ball-grid array IC package 2100 has a plurality of connection elements, which in this case are pads, 2101 on each of which a metal (preferably gold) ball 2102 has been bonded or solder reflow attached.

Referring now to Figure 22, a package carrier 2201 has been adapted for the mounting of a pair of ball-grid array IC packages 2100-A and 2100-B, which in this view, are positioned for mounting thereon. Each of the balls 2102 will be physically and electrically bonded to a corresponding pad 2202 on the carrier 2201. Bonding can be via solder reflow, via vibrational energy input, or any other known technique. Likewise, a pair of ball-grid array IC packages 2100-C and 2100-D are positioned for mounting on a portion of a printed circuit board 2203 beneath the carrier 2201. It will be noted that the printed circuit board 2203 includes a mounting pad array 2204 that will be used exclusively by the package carrier 2201. Each of the lower ball-grid array IC packages 2100-C and 2100-D are interfaced to printed circuit board circuitry (not shown) through their own mounting pad arrays 2205-C and 2205-D.

Referring now to the assembled fourth embodiment electronic module 2300 of Figure 23, assembly of the components shown in Figure 22 has resulted in a printed circuit board assembly having two ball-grid-array type packages (2100-C and 2100-D) covered by carrier 2201, on which two additional ball-grid-array type packages (2100-A and 2100-B) are mounted. Figure 24 shows eight Figure 23 assemblies incorporated in a single DIMM module 2400.

Referring now to Figure 25, an assembled fifth embodiment electronic module 2500 is similar to that of Figure 23, with the exception that the carrier 2501 is designed to receive only a single ball-grid-array IC package 2502-A. An additional ball-grid-array IC package 2502-B is positioned beneath the carrier 2501. Both the carrier 2501 and IC package 2502-B are bonded to the printed cithe s and two such packages mounted on a portion of a printed circuit board.

Although only several single embodiments of the invention have been heretofore described, it will be obvious to those having ordinary skill in the art that changes and modifications may be made thereto without departing from the scope

and the spirit of the invention as hereinafter claimed. For example, many variations of two basic embodiments are possible. For example, the leads of surface mount IC packages may vary. In addition, the shape of the outer portions of the carrier leads may also vary from the "C" shape disclosed herein. At the present time, two types of leads are most commonly used for surface mount components. One lead is "J"-shaped; the other is "S"-shaped. The "S", or gull-wing-shaped, leads are becoming increasingly widespread. Other types of leads for surface-mount components may also be developed. For example, butt-joint leads are also coming into common usage because they provide connection in a minimum amount of space. Only the ends of such leads are soldered to a connector pad. The invention should not be considered limited by the type of leads which are utilized on any of the constituent components or on the chip carrier 101. Lead types may also be mixed between components comprising a module. Thus, assemblies having a number of different lead combinations are possible. At one end of the spectrum, both packages and the carrier may utilize "C"-shaped or "J"-shaped leads. At the other end, all components will use "S"-shaped leads. Between those two extremes, each of the components may utilize either of the three leads currently available for surface-mount components, as well as leads which might be developed. In addition, the surface mounting of components typically involves a solder reflow process, where leads and/or mounting pads are coated with a solder emulsion. The components are then assembled and the assembly is subjected to a reflow step in an oven. The leads are thus conductively bonded to the mounting pads. There are other known techniques for bonding leads to mounting pads. Placing a metal ball (usually gold) on each of the mounting pads, placing a lead on top of each ball, and using ultrasonic energy to fuse each ball to both its associated pad and lead is another surface mount option.

CLAIMS

What is claimed is:

1. An electronic module comprising:

first and second sets of IC packages, each set comprising at least one package, and each package having a package body containing an integrated circuit chip and a plurality of connection elements coupled to said chip;

at least one IC package unit having a carrier with at least one mounting location thereon for conductively bonding thereto the connection elements of said at least one package of said first-set IC package, said carrier also having a set of carrier leads which extend outwardly and downwardly from said at least one mounting location, thereby forming a recess within which said second-set IC package may be nested;

a printed circuit board having at least one surface-mount pad array thereon, said at least one pad array having conductively bonded thereto both said leads of said carrier of said at least one IC package unit and the connection elements of said at least one pacakge of said nested second-set IC package.

2. The electronic module of claim 1, wherein said carrier comprises only a set of leads to which the connection elements of said at least one package of said first-set IC package are conductively bonded.

3. The electronic module of claim 2, which further comprises an adhesive film strip bonded to all the leads beneath said mounting location.

4. The electronic module of claim 3, wherein said adhesive film strip is a thermo-conductive dielectric material.

5. The electronic module of claim 4, wherein said adhesive filmstrip is in contact with said nested second-set IC package.

6. The electronic module of claim 1, wherein said carrier comprises a dielectric carrier body having upper and lower parallel major planar surfaces, said mounting

location positioned on said upper major planar surface, said carrier leads being affixed to said lower major planar surface, electrical connection between said carrier leads and said mounting location provided by conductively plated apertures which extend between said upper and lower major planar surfaces.

7. The electronic module of claim 1, wherein each of said first and second set IC packages are of a ball-grid-array type, and separate pads of said at least one surface-mount pad array on the printed circuit board are employed for mounting of said at least one IC package unit and said nested second-set IC package.

8. The electronic module of claim 6, which further comprises at least one decoupling capacitor mounted on said at least one IC package unit.

9. The electronic module of claim 1, wherein each carrier lead includes a laminar extension which is parallel to and contiguous with said lower major planar surface.

10. The electronic module of claim 9, wherein only those carrier leads which are designed to be at either ground potential or at supply voltage potential during operation of said first set IC package have laminar extensions which function as heat sinks.

11. The electronic module of claim 6, wherein said dielectric body is formed from fiberglass-reinforced plastic material.

12. The electronic module of claim 1, wherein a single surface-mount pad array is employed for bonding both [the] said at least one IC package unit and said second-set IC package.

13. The electronic module of claim 12, wherein at least one pad of said surface-mount pad array is split so that corresponding connection elements of said first-set packages and second-set packages may receive unique signals.

14. The electronic module of claim 6, wherein a single surface-mount pad array is employed for bonding both said at least one IC package unit and said nested second-set IC package, and wherein unique signals are fed to corresponding connection elements of a first-set IC package and a second-set IC package nested within said at least one IC package unit to which said first-set IC package is bonded by routing at least one of the signals to an unused connection element position on said second-set IC package, and then rerouting the signal within the carrier body to the appropriate bonding location for a desired connection element on said first-set IC package.

15. The electronic module of claim 1, wherein said first-set and second-set IC packages are of the same size and functionally identical.

16. An electronic module comprising:

first and second sets of IC packages, each set comprising at least one package, and each package having a package body containing an integrated circuit chip and a plurality of connection elements coupled to said chip;

at least one IC package unit having a carrier with a bonding location for each connection element of said at least one package of said first-set IC package, all bonding locations residing in a common plane, said carrier also having a set of carrier leads, each of which is electrically coupled to a bonding location, said leads extending downwardly from said plane, thereby forming a recess within which said second-set IC package may be nested;

a printed circuit board having at least one surface-mount pad array thereon, each surface-mount pad array having conductively bonded thereto both said leads of said carrier of said at least one IC package unit and the connection elements of said at least one pacakge of said nested second-set IC package.

17. The electronic circuit module of claim 16, wherein said carrier comprises only a set of leads to which the connection elements of said at least one package of said first-set IC package are conductively bonded.

18. The electronic module of claim 17, which further comprises an adhesive dielectric film strip bonded to all the leads beneath said mounting location.

19. The electronic module of claim 18, wherein said adhesive film strip is a thermo-conductive material.

20. The electronic module of claim 19, wherein said adhesive film strip is in contact with said nested second-set IC package.

21. The electronic module of claim 16, wherein said carrier comprises a dielectric carrier body having upper and lower parallel major planar surfaces, said bonding locations are positioned on said upper major planar surface, said carrier leads are affixed to said lower major planar surface, and electrical connection between said carrier leads and said bonding locations is effected by conductively plated apertures which extend between said upper and lower major planar surfaces.

22. The electronic module of claim 16, wherein each of said first and second set IC packages are of a ball-grid-array type and separate pads of said at least one surface-mount pad array on the printed circuit board are employed for mounting of said at least one IC package unit and said nested second-set IC package.

23. The electronic module of claim 21, which further comprises at least one decoupling capacitor mounted on said at least one IC package unit.

24. The electronic module of claim 16, wherein each carrier lead includes a laminar extension which is parallel to and contiguous with said lower major planar surface.

25. The electronic module of claim 24, wherein only those carrier leads which are designed to be at either ground potential or at supply voltage potential during operation of said first set IC package have laminar extensions which function as heat sinks.

26. The carrier of claim 21, wherein said dielectric body is formed from fiberglass-reinforced plastic material.

27. The package carrier of claim 21, which further comprises at least one pair of capacitor mounting pads on said upper major planar surface, each pair sized and spaced to receive a decoupling capacitor.

28. The electronic circuit module of claim 16, wherein a single surface-mount pad array is employed for bonding both said at least one IC package unit and said nested second-set IC package.

29. The electronic circuit module of claim 28, wherein at least one pad of said surface-mount pad array is split so that corresponding connection elements of said first-set packages and second-set packages may receive unique signals.

30. The electronic module of claim 21, wherein a single surface-mount pad array is employed for bonding both said at least one IC package unit and a nested second-set IC package, and wherein unique signals are fed to corresponding connection elements of a first-set IC package and a second-set IC package nested within said at least one IC package unit to which said first-set IC package is bonded by routing at least one of the signals to an unused connection element position on the second-set IC package, and then rerouting the signal within the carrier body to the appropriate bonding location for a desired connection element on the first-set IC package.