grooves 116 that are arranged in a sequence of discrete grooves that are alternately staggered along and around the die pad rim 114 preferable on three or four sides of the die pad 104. The grooves 116 thus form a discrete, alternately staggered surface configuration in the die pad 104 that creates more space in the die pad 104 for connecting and separating the ground bond wire-bonds 110c and the down bond wire-bonds 110d. The ground bond wire-bonds 110c and the down bond wire-bonds 110d can be attached on sides of the grooves 116 opposite the die 106 and sides of the grooves facing the die 106. The grooves also serve the additional purpose of locking the mold compound encapsulant (not shown, but see the encapsulant 202 in FIG. 2) firmly to the die pad 104. The ground connection of the various ground bond wire-bonds 110c and the down bond wire-bonds 110d to the die pad rim 114 of the die pad 104 is thus efficiently accomplished without a separate ground ring such as would be otherwise conventionally disposed between the die pad 104 and the leads 102 of the leadframe 100.

Based on this disclosure, it will now be clear to one of ordinary skill in the art that the shape, size, positions, and number of rows of staggered grooves can be optimized in relation to the size of the die, the size of the die pad, and the number and spacing (or density) of the ground bond wire-bonds and down bond wire-bonds. For example, more staggered rows of the grooves can be designed and incorporated into the die pad rim if the die size is small compared to the die pad size, and vice versa. Also, the lengths and positions of the grooves can be designed flexibly to suit the positions of the ground bond wire-bonds and down bond wire-bonds in various IC designs. Further, since the grooves are separation structures for separating the ground bond wire-bonds and the down bond wire-bonds, it will be understood that the groove structures can be seen as providing raised as well as depressed areas.

Referring now to FIG. 2, therein is shown a cross-sectional view of a package 200 formed by encapsulating the leadframe 100, the die 106, and the wire-bonds 110 in an encapsulant 202. The FIG. 2 sectional view corresponds generally to the section line 2–2 through the assembly shown in FIG. 1. Also shown in FIG. 2 is an adhesive 204, such as solder or a layer of epoxy, that adheres the die 106 to the die pad 104. The die pad 104 includes an inner raised surface 205 and an outer raised surface 206 of the die pad rim 114. One of the grooves 116 is between the inner raised surface 205 and the outer raised surface 206. The inner raised surface 205 and one of the grooves 116 are between the die 106 and the outer raised surface 206. The ground bond wire-bonds 110c can be attached between the leads 102 and the inner raised surface 205 of the die pad rim 114.

Referring now to FIG. 3, therein is shown a plan view of a leadframe 300 according to another embodiment of the present invention. The leadframe 300 may be manufactured from a single flat sheet of material, usually metal, in a single stamping, cutting, and forming process. Alternatively, the leadframe 300 may be manufactured using an etch process, which can avoid constraints caused by tool making issues that are typical in certain stamping processes.

The leadframe 300 also includes a number of leads 102 around the periphery thereof. The leads 102 may be held in position by conventional tie bars (not shown) until the

incorporated into the die pad rim if the die size is small compared to the die pad size, and vice versa. Also, the sizes and positions of the X-shaped grooves can be designed flexibly to suit the positions of the ground bond wire-bonds and down bond wire-bonds in various IC designs. Further, since the X-shaped grooves are separation structures for separating the ground bond wire-bonds and the down bond wire-bonds, it will be understood that the groove structures can be seen as providing raised as well as depressed areas.

Referring now to FIG. 4, therein is shown a cross-sectional view of a package 400 formed by encapsulating the leadframe 300, the die 106, and the wire-bonds 110 in an encapsulant 202. The FIG. 4 sectional view corresponds generally to the section line 4–4 through the assembly shown in FIG. 3. Also shown in FIG. 4 is an adhesive 204, such as solder or a layer of epoxy, that adheres the die 106 to the die pad 304. The ground bond wire-bonds 110c are attached from the leads 102 to a raised surface 401 of the peripheral die pad rim 314.

Referring now to FIG. 5, therein is shown a plan view of a leadframe 500 according to yet another embodiment of the present invention. The leadframe 500 may be manufactured from a single flat sheet of material, usually metal, in a single stamping, cutting, and forming process. Alternatively, the leadframe 500 may be manufactured using an etch process, which can avoid constraints caused by tool making issues that are typical in certain stamping processes.

The leadframe 500 includes a number of leads 102 around the periphery thereof. The leads 102 may be held in position by conventional tie bars (not shown) until the leadframe is encapsulated in a package (not shown, but see the package 600 in FIG. 6). In the center of the leadframe 500 is located a frame paddle that serves as a die pad 504 for attaching, mounting, and supporting a semiconductor device, such as a die 106, in the center of the leadframe 500. The die pad 504 is supported in this position by one or more corner tie bars 108 that are elongated inwardly to connect to and support the die pad 504.

Wire-bonds 110 wire-bond the die 106 to the leadframe 500. In particular, the wire-bonds 110 connect die wire-bonding pads 112 on the die 106 to the leads 102 of the leadframe 500 and to the die pad 504. The wire-bonds 110 include, for example, power wire-bonds 110a, signal wire-bonds 110b, ground bond wire-bonds 110c, and down bond wire-bonds 110d. For clarity of illustration only a few of the wire-bonds 110 are shown, but it will be understood that numerous wire-bonds of various types are attached between the die wire-bonding pads 112, the leads 102, and the die pad 504.

For accommodating the ground bond wire-bonds 110c and the down bond wire-bonds 110d, the lateral dimensions of the die pad 504 are larger than those of the die 106 that is

THE INVENTION CLAIMED IS:

1. A method for fabricating an integrated circuit leadframe, comprising:

forming a leadframe having leads around a die pad, the die pad includes ~~that has~~ a peripheral die pad rim; ~~and~~

adhering a die to the die pad;

forming a ~~discrete, alternately staggered~~ surface configuration in the peripheral die pad rim including an inner raised surface, grooves, and an outer raised surface; the inner raised surface and one of the grooves being between the die and the outer raised surface; and~~that~~:

~~creates space in the die pad for connecting and separating ground bond wire-bonds and down bond wire-bonds; and~~

~~provides for locking encapsulant firmly to the die pad.~~

attaching ground bond wire-bonds from the leads to the inner raised surface of the peripheral die pad rim, whereby the surface configuration is for providing clearance space for the ground bond wire-bonds from other wire-bonds.

2. The method of claim 1 wherein forming the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~includes forming depressed separation structures.

3. The method of claim 1 wherein forming the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~ includes forming a sequence of discrete~~;~~, alternately staggered grooves.

4. The method of claim 1 wherein forming the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~ includes forming ~~a sequence of~~ X-shaped grooves for forming a discrete, alternately staggered surface configuration in the die pad ~~surface configurations~~.

5. The method of claim 1 wherein forming the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~includes forming ~~a sequence of~~ U-shaped grooves for forming a discrete, alternately staggered surface configuration~~s~~ in the die pad.

6. A method for fabricating an integrated circuit leadframe, comprising:

forming a leadframe from a single flat sheet of material in a single manufacturing process, the leadframe having leads around a die pad, the die pad includes ~~that has~~ a peripheral die pad rim;

forming a ~~discrete, alternately staggered~~ surface configuration in the peripheral die pad rim ~~that~~ including an inner raised surface, grooves, and an outer raised surface;~~:~~

~~creates space in the die pad for connecting and separating ground bond wire-bonds and down bond wire-bonds; and~~

~~provides for locking encapsulant firmly to the die pad;~~

adhering a semiconductor device to the die pad, the inner raised surface and one of the grooves being between the semiconductor device and the outer raised surface;

attaching ground bond wire-bonds from the leads to the inner raised surface of the peripheral die pad rim, whereby the surface configuration is for providing clearance space for the ground bond wire-bonds from other wire-bonds;

wire-bonding the semiconductor device to the leadframe; and

encapsulating at least portions of the semiconductor device and the leadframe.

7. The method of claim 6 wherein forming the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~ includes forming depressed separation structures.

8. The method of claim 6 wherein forming the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~ includes forming a sequence of discrete; alternately staggered grooves.

9. The method of claim 6 wherein forming the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~includes forming ~~a sequence of~~ X-shaped grooves for forming a discrete, alternately staggered surface configuration~~s~~ in the die pad.

10. The method of claim 6 wherein forming the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~includes forming ~~a sequence of~~ U-shaped grooves for forming a discrete, alternately staggered surface configuration~~s~~ in the die pad.

11. A leadframe for an integrated circuit, comprising:

a die pad having;

a peripheral die pad rim on the die pad, and;

a surface configuration having ~~a~~ an inner raised surface, grooves, and an outer raised surface on the peripheral die pad rim;

a die mounted on the die pad, the inner raised surface and one of the grooves being between the die and the outer raised surface;

leads around the peripheral die pad rim; and

~~a discrete, alternately staggered surface configuration in the die pad rim that:~~

~~creates space in the die pad for connecting and separating ground bond wire-bonds and down bond wire-bonds; and~~

~~provides for locking encapsulant firmly to the die pad~~

ground bond wire-bonds attached from the leads to the inner raised surface of the peripheral die pad rim, whereby the surface configuration is for providing clearance space for the ground bond wire-bonds from other wire-bonds.

12. The leadframe of claim 11 wherein the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~ includes depressed separation structures.

13. The leadframe of claim 11 wherein the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~ includes a sequence of discrete~~;~~, alternately staggered grooves.

14. The leadframe of claim 11 wherein the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~ includes ~~a sequence of~~ X-shaped grooves for forming a discrete, alternately staggered surface configuration~~s~~ in the die pad.

15. The leadframe of claim 11 wherein the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~ includes ~~a sequence of~~ U-shaped grooves for forming a discrete, alternately staggered surface configuration~~s~~ in the die pad.

16. A leadframe for an integrated circuit, comprising:

a die pad having:~~;~~

a peripheral die pad rim on the die pad, and

a surface configuration having an inner raised surface, grooves, and an outer raised surface on the peripheral die pad rim;

a die mounted on the die pad, the inner raised surface and one of the ~~grooves between~~ grooves being between the die and the outer raised surface;

leads around the peripheral die pad rim;

~~the die pad and leads being formed from a single flat sheet of material in a single manufacturing process;~~

ground bond wire-bonds attached from the leads to the inner raised surface of the peripheral ~~–~~die pad rim, whereby the surface configuration is for providing clearance space for the ground bond wire-bonds from other wire-bonds; and

~~a discrete, alternately staggered surface configuration in the die pad rim that:~~

~~creates space in the die pad for connecting and separating ground bond wire-bonds and down bond wire-bonds; and~~

~~provides for locking encapsulant firmly to the die pad;~~

~~a semiconductor device adhered to the die pad;~~

~~the semiconductor device being wire bonded to the leadframe; and~~

an encapsulant encapsulating at least portions of the ~~semiconductor device~~ die and the lead~~sframe~~.

17. The leadframe of claim 16 wherein the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~ includes depressed separation structures.

18. The leadframe of claim 16 wherein the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~ includes a sequence of discrete~~;~~, alternately staggered grooves.

19. The leadframe of claim 16 wherein the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~ includes ~~a sequence of~~ X-shaped grooves for forming a discrete, alternately staggered surface configuration~~s~~ in the die pad.

20. The leadframe of claim 16 wherein the ~~discrete, alternately staggered~~ surface configuration ~~further comprises~~ includes ~~a sequence of~~ U-shaped grooves for forming a discrete, alternately staggered surface configuration~~s~~ in the die pad.