Carrier for electronic components and methods for encapsulating and separating an electronic component

The invention relates to a carrier provided with an electronic component connected to the carrier, and to a carrier for mounting of at least one electronic component. The invention also relates to a method for encapsulating an electronic component connected to a carrier, and to a method for separating from a carrier an electronic component mounted on a carrier.

The encapsulation of electronic components, such as semiconductors in particular, after they have been placed on a carrier, such as leadframes or boards in particular, takes place on a large scale. According to the prior art a carrier is placed for this purpose in a mould in which mould cavities are left clear at the locations of the encapsulations to be arranged. Liquid encapsulant, such as epoxy in particular, is then fed under pressure to the mould cavities and cures in the mould cavity. After (partial) curing of the encapsulant, the mould is removed from the carrier and the desired encapsulation is realized. This encapsulating technique is applied on a large scale. The drawback of the existing encapsulating technique is that the moulds are complex and expensive and generally product-dependent, so that specific moulds are required for each type of product.

US patent 6,458,628 discloses methods of encapsulating a semiconductor chip using a settable encapsulant. The semiconductor chip is attached to a dielectric layer that thus acts as a carrier for the chip. The dielectric layer is placed into a mold that sealingly engages on the dielectric layer. After disposing a liquid composition in the mold the liquid is partly cured such that a cured skin and an uncured portion rests, then the dielectric layer is moved from the mold and the uncured portion of the liquid is cured outside the mold. Also disclosed is a frame that is attached to the dielectric layer for handling aligning the dielectric layer during various processing steps.

The object of the present invention is to provide a modified technique for encapsulating electronic components placed on a carrier, wherein the existing, relatively complex moulds become unnecessary, with all the associated advantages.

The invention provides for this purpose a carrier provided with an electronic component connected to the carrier, according claim 1. The recess can for instance take the form of an aperture. The recess in the carrier is preferably formed by a recess opened on one side. The recess arranged in the carrier thus forms (at least partly) the mould cavity in which the encapsulant can be arranged. The mould cavity therefore need no longer be (wholly) defined by a mould part. This is because according to the present invention the function of the mould is (at least partially) integrated with the carrier of the electronic component. The product-dependent mould cavity is thus coupled (at least partially) to the product, which renders product-dependent mould parts (at least partially) unnecessary. This can result in a considerable reduction in tooling costs and to simplified change-over of the products for processing in an encapsulating device. A further significant advantage of the carrier according to the invention is that the chance of errors is reduced when arranging an encapsulation around an electronic component. The release of a manufactured encapsulation (housing) from a mould part is a process step where damage to the housing can occur, there is the chance of delamination, the mould cavities in a mould part can be contaminated and/or other problems can occur.

A method of manufacturing a flexible integrated circuit package utilizing an integrated carrier ring/stiffener is disclosed in US 6,284,569. The carrier ring as disclosed provides a stiffening function to a substrate and is as such not forming part of the carrier. The ring/stiffener can further provide also extra functions like providing ridge functions, vents and/or gates. The ring/stiffener is not part of the carrier and is thus not providing a carrier holding a recess that is an integral part of the carrier according the present invention.

The process step of releasing a manufactured encapsulation from a mould part becomes (at least partially) unnecessary with the carrier according to the present invention and will therefore also result in a reduced chance of errors. The once-only use of the recess arranged in the carrier during manufacture of an encapsulation (in contrast to the multiple use of a mould cavity in a conventional mould part) moreover reduces the need to clean the encapsulating device. A further advantage is that by means of the carrier according to the invention the encapsulation of an electronic component is (at least partially) embedded in the carrier, so that an improved adhesion between the carrier and the housing can be realized and whereby the carrier with housing already becomes

manipulable when a housing is cured in relatively small measure. This results in the additional advantage that the cycle time of an encapsulating operation can be reduced. It is also advantageous that before application of the encapsulant the electronic component is already partly shielded in that it lies (at least partially) in the recess. During manipulation of the carrier prior to the encapsulating operation the chance is thus reduced of damaging the electronic component and the usually vulnerable connections of the electronic component to the carrier.

In a particular preferred embodiment, the recess is open to a flat side of the carrier. The electronic components are after all generally placed on a flat side of a carrier. It is also advantageous if a single recess receives a plurality of electronic components. A plurality of electronic components can thus be covered simultaneously with a single body of encapsulant. In an extreme variant this results in a carrier with a standing peripheral edge, the whole inner side of which functions as recess and in which between one and a very large number of electronic components can be positioned. In yet another variant, the carrier is provided with a plurality of recesses (apertures), each provided with at least one electronic component located at least partially therein.

The recess can be arranged in a carrier layer forming an integral part of the carrier. It is possible here to envisage for instance a board with profiled upper layer such that openings are arranged in the electrically non-conductive material of composite carriers (substrate). Such a carrier can already be provided during the production stage of the carrier (the substrate) with such a profiled surface, although it is also possible to arrange the recess(es) therein later (i.e. after production of the carrier). It is also possible to provide the carrier with a mask forming part of the carrier, in which mask the recess is arranged. Such a mask can for instance be formed by a foil material connected to the carrier (for instance by a sticker which can be adhered to the carrier). Conversely, the mask can also be at least partially formed by a masking plate connected to the carrier, for instance a masking plate manufactured from cardboard or plastic which is connected to the carrier.

The invention also comprises the carrier as described above, wherein the recess in the carrier is at least partially filled with an encapsulant. The encapsulant may or may not be fully cured here such that the at least one electronic component placed in the recess

is at least partially encapsulated by encapsulant. The at least partial encapsulation of the electronic component refers to the option of the electronic component being fully enclosed by encapsulant as well as to the variant of the electronic component remaining partially free of encapsulant, whereby it can function for instance as sensor or detector, or whereby an improved heat generation of the component to the environment is made possible.

In yet another embodiment variant, the carrier is also provided with a runner connecting to the recess and recessed into the carrier. The runner can herein optionally be provided with a narrowed passage (gate) at the position where the runner connects to the recess in the carrier. Injection of the encapsulant can thus also take place through the channel arranged in the carrier. The narrowed passage in the runner is less obvious according to the invention than in the prior art because products encapsulated according to the invention generally no longer have the feed removed. According to the invention the products can be separated directly from the carrier with supplied encapsulant without removing the feed. Heretofore runners formed components of a mould which were susceptible to wear and required frequent maintenance. Now that they can be integrated with the carrier, the runners are only used once and at least some of the drawbacks of the prior art runners are no longer present.

In yet another preferred embodiment, the recess arranged in the carrier is covered with a foil layer connecting to the carrier. The layer of foil material thus provides a shielding of the encapsulant with a mould part connecting to the mould cavity. A runner possibly arranged in the carrier can also be covered by the foil material in order to thus make impossible the adhesion to a mould part of the encapsulant in the runner.

The carrier before an electronic component is mounted thereon according claim 12 also forms part of the present invention. An advantage of such a carrier compared to conventional carriers is that the electrically conductive contact positions are partly shielded (particularly when the carrier is stacked) because they are located in the recess arranged in the carrier. In accordance with the above description in respect of the carrier provided with at least one electronic component, the carrier can be provided with a plurality of recesses, the recess can be arranged in a carrier layer forming an integral

part of the carrier and/or the carrier can be provided with a mask forming part of the carrier, in which mask the recess is arranged.

In addition, the invention provides a method for encapsulating an electronic component connected to a carrier according claim 18. Encapsulating is here understood to mean that the electronic component is at least partially enclosed with an encapsulant. The encapsulant is herein normally fed in liquid form to the recess in the carrier during processing step B) and cured during processing step C). The chance of leakage (bleed and flash) of (components of) the encapsulant is reduced considerably by feeding encapsulant into the recess. The recess can after all be embodied as a recess open only at the top, whereby undesirable outflow/leakage of encapsulant on the underside is impossible. In addition to the advantages already described above in respect of the carrier according to the invention, the closing force of an encapsulating device required for the encapsulation has moreover become unnecessary. The encapsulant can theoretically be introduced (poured) into the recess without applying any (over)pressure to the encapsulant. During curing the encapsulant placed in the recess can be contacted by a mould part so as to influence the form in which the encapsulant cures. Most obvious here is to close the recess in the carrier with the electronic component placed therein using a substantially flat mould part.

In a preferred application of the method, the carrier is positioned during processing step C) in stationary manner relative to a holder part engaging the carrier, and the encapsulant is contacted by a substantially flat plate which is displaceable relative to the holder part. It is possible here to envisage the use of a prior art encapsulating device in which at least one mould part, in which mould cavities were formerly provided, is replaced by a flat plate. Such a modification to an encapsulating device can be realized in very simple manner. The method can thus be applied without any problem using prior art encapsulating equipment.

The method does however also make it possible to perform the encapsulating operation in wholly different manner. The carrier can thus be displaced during processing step C) by a movable holder part engaging on the carrier, and a mould part which likewise engages the carrier can simultaneously be advanced parallel to the carrier. Both the carrier and the mould part can herein form part of endless conveyors. Encapsulation can

thus be performed as a continuous process in a device which can be of very simple construction compared to the existing encapsulating equipment. It is moreover possible here to further increase the efficiency of encapsulation of electronic components mounted on a carrier by simultaneously encapsulating a plurality of electronic components placed in a single recess in the carrier and connected to the carrier, and/or by simultaneously feeding encapsulant to a plurality of recesses in the carrier.

In addition, the invention further provides a method for separating from a carrier an electronic component mounted on the carrier, according claim 26. It is thus unnecessary to remove the means forming the recess, such as for instance a carrier layer, a foil material and/or a mask, after the encapsulant is fed to a recess in the carrier as described above. The electronic component at least partially encapsulated with encapsulant (i.e. the component including an enclosing part of cured encapsulant) can be removed directly from the carrier by means of diverse processing techniques such as for instance diamond sawing, (laser) cutting or other common separating technique. Parts of the carrier enclosing the recess can also be separated during the separation.

The invention will be further elucidated on the basis of the non-limitative exemplary embodiments shown in the following figures, in which:

figure 1A shows a perspective view of a carrier according to the invention provided with two recesses with an electronic component placed therein,

figure 1B shows a perspective view of an alternative embodiment variant of a carrier according to the invention provided with two recesses which are provided in a material layer forming part of the carrier, with a plurality of electronic components placed in each recess,

figure 2 is a perspective view of a carrier according to the invention provided with only a grid of contact positions, to which contact positions electronic components can be connected,

figure 3A is a perspective view of a carrier according to the invention provided with two recesses which are filled with encapsulant,

figure 3B is a perspective view of an alternative embodiment variant of a carrier according to the invention provided with two recesses filled with encapsulant, in which recesses a plurality of electronic components are placed which are only partially encapsulated with encapsulant,

figure 4A shows a schematic cross-section through an encapsulating device having a carrier according to the present invention placed therein, before commencement of the encapsulating operation according to the present invention,
figure 4B shows a schematic cross-section through the encapsulating device of figure 4A during the encapsulating operation, and
figure 5 is a perspective view of a schematically shown separating device during performing of a separating method according to the present invention.

Figure 1A shows a carrier 1 in which two recesses 2 are left clear. Electronic components 3 are placed in recesses 2. An alternatively embodied carrier 4 is shown in figure 1B. Two recesses 5 are likewise left clear in this carrier 4, although the recesses 5, other than in the case of the carrier 1 shown in figure 1A, are now situated in a material layer 6 forming part of carrier 4. This material layer 6 can consist of for instance a foil material, cardboard or random other material. Material layer 6 can be adhered to a rigid bottom layer 10, or the connection between material layer 6 and bottom layer 10 can be effected in other manner. A plurality of electronic components 7 are placed in each of the thus obtained recesses 5. Runners 8 are also recessed into carrier 1 for feed to recesses 2 in carrier 1. Recesses 2 and runners 8 are moreover covered by a layer of foil material 9. The form of the runners can be optimized subject to the conditions in which they are applied.

Figure 2 shows a carrier 20, a material layer 21 of which forms the periphery of a recess 22. Other than in carrier 1 and 6 as shown in figures 1A and 1B, the carrier is not provided with an electronic component but only with a grid of connections or contact points 23 to which one or more electronic components can be connected. Such a carrier 20, without electronic component, also forms part of the present invention.

Figure 3A shows a carrier 30, of which recesses (not shown) are filled with encapsulant 31. Carrier 32 as shown in figure 3B is also provided with recesses filled with encapsulant 33. Carrier 32 is assembled from a bottom layer 34 and a top layer 35. Encapsulant 33 is arranged such that a part of the electronic components 36 for encapsulating remains free of encapsulant 33. This is particularly desirable in the case of electronic components 36 which in the encapsulated state must communicate in specific manner with the environment, for instance by means of detecting determined

signals, generating determined signals, and/or heat transfer. Use can advantageously be made of covering foil parts 37 for the purpose of leaving electronic components 36 partially free. In carrier 30 can moreover be seen two runners 38 filled with encapsulant which are also covered by foil parts 37.

Figure 4A shows schematically an encapsulating device 40 provided with two mould halves 41, 42, the mutual distance of which is adjustable. In the open position of encapsulating device 40 as shown in figure 4A, a carrier 43 according to the invention can be placed in the lower mould half 41 (or be removed from mould half 41 after encapsulation). For a stable orientation of carrier 43 in relation to lower mould half 41, this latter is provided in the shown embodiment with a receiving space 44 arranged for this purpose. Upper mould half 42 comprises a flat plate in which a number of options are shown schematically here for runners 45 for encapsulant, which in practice will probably not all be present at the same time. The feed of the encapsulant can take place in any desired manner, wherein particularly the use of a plunger, with which liquid encapsulant can be injected, forms a frequently occurring solution. It is furthermore noted that runners 45 for encapsulant can also be arranged in the lower mould half 41, and are moreover usually arranged as channels on the contact sides of one of the mould halves.

Figure 4B shows encapsulating device 40 in the situation where mould halves 41, 42 close onto each other. Encapsulant 46 has already been arranged in the recesses 47 which are arranged for this purpose in carrier 43 and in which the electronic components 48 for encapsulating are situated. Shown clearly is that the flat form of upper mould half 42 (apart from runners 45 which, as already described above, can also be situated elsewhere) represents a considerable simplification compared to prior art mould halves in which mould cavities are arranged with great precision and in wear-resistant manner.

Finally, figure 5 shows a separating device 60 with a saw 61 which rotates as according to arrow P2 and which is driven by a motor 62. A carrier 63, in which the formerly present recesses are now filled with cured encapsulant 64, lies on a supporting table 65 displaceable in a plane 66. By displacing the supporting table 65 (including for instance

rotation in the plane 66) carrier 63 can be moved under saw 61 such that carrier 63 can be divided into segments as required.

Claims

1. Carrier (1, 4, 10, 20, 30, 43, 63) provided with an electronic component (3, 7, 36, 48) connected to the carrier (1, 4, 10, 20, 30, 43, 63), wherein the electronic component (3, 7, 36, 48) lies at least partially in a recess (2, 5, 22, 47), **characterised in that** the recess (2, 5, 22, 47) is an integral part of the carrier (1, 4, 10, 20, 30, 43, 63) for receiving and holding liquid encapsulant (31, 33, 46, 64).

2. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in claim 1, **characterized in that** the recess (2, 5, 22, 47) in the carrier (1, 4, 10, 20, 30, 43, 63) is formed by a recess (2, 5, 22, 47) open on one side.

3. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in claim 1 or 2, **characterized in that** the recess (2, 5, 22, 47) is open to a flat side of the carrier (1, 4, 10, 20, 30, 43, 63).

4. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in any of the foregoing claims, **characterized in that** a recess (2, 5, 22, 47) receives a plurality of electronic components (3, 7, 36, 48).

5. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in any of the foregoing claims, **characterized in that** the carrier (1, 4, 10, 20, 30, 43, 63) is provided with a plurality of recesses (2, 5, 22, 47), each provided with an electronic component (3, 7, 36, 48) located at least partially therein.

6. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in any of the foregoing claims, **characterized in that** the carrier (1, 4, 10, 20, 30, 43, 63) is provided with a mask forming part (6, 21) of the carrier (1, 4, 10, 20, 30, 43, 63), in which mask (6, 21) the recess (2, 5, 22, 47) is arranged.

7. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in claim 6, **characterized in that** the mask (6, 21) is formed by a foil material (9) connected to the carrier (1, 4, 10, 20, 30, 43, 63).

8. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in claim 6 or 7, **characterized in that** the mask (6, 21) is at least partially formed by a masking plate (6, 21) connected to the carrier (1, 4, 10, 20, 30, 43, 63).

9. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in any of the foregoing claims, **characterized in that** the recess (2, 5, 22, 47) in the carrier (1, 4, 10, 20, 30, 43, 63) is at least partially filled with an encapsulant (31, 33, 46, 64).

10. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in any of the foregoing claims, **characterized in that** the carrier (1, 4, 10, 20, 30, 43, 63) is also provided with a runner (8, 38) connecting to the recess (2, 5, 22, 47) and recessed into the carrier (1, 4, 10, 20, 30, 43, 63).

11. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in any of the foregoing claims, **characterized in that** the recess (2, 5, 22, 47) arranged in the carrier (1, 4, 10, 20, 30, 43, 63) is covered with a foil layer (9) connecting to the carrier (1, 4, 10, 20, 30, 43, 63).

12. Carrier (1, 4, 10, 20, 30, 43, 63) for mounting at least one electronic component (3, 7, 36, 48), comprising:
- a number of contact positions (23) for realizing electrically conductive connections to the electronic component (3, 7, 36, 48) to be mounted, and
- a recess (2, 5, 22, 47) for at least partially receiving the electronic component (3, 7, 36, 48) to be mounted,
characterised in that the recess (2, 5, 22, 47) forming an integral part of the carrier (1, 4, 10, 20, 30, 43, 63) for receiving and holding liquid encapsulant (31, 33, 46, 64).

13. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in claim 12, **characterized in that** the electrically conductive positions (23) are located at least partially in the recess (2, 5, 22, 47) arranged in the carrier (1, 4, 10, 20, 30, 43, 63).

14. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in claim 12 or 13, **characterized in that** the carrier (1, 4, 10, 20, 30, 43, 63) is provided with a plurality of recesses (2, 5, 22, 47).

15. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in any of the claims 12-14, **characterized in that** the carrier (1, 4, 10, 20, 30, 43, 63) is provided with a mask (6, 21) forming part of the carrier (1, 4, 10, 20, 30, 43, 63), in which mask (6, 21) the recess (2, 5, 22, 47) is arranged.

16. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in any of the claims 12-15, **characterized in that** the carrier (1, 4, 10, 20, 30, 43, 63) is also provided with a runner (8, 38) connecting to the recess (2, 5, 22, 47) and recessed into the carrier (1, 4, 10, 20, 30, 43, 63).

17. Carrier (1, 4, 10, 20, 30, 43, 63) as claimed in claim 16, **characterized in that** the runner (8, 38) is provided with a narrowed passage at the position where the runner (8, 38) connects to the recess (2, 5, 22, 47) in the carrier (1, 4, 10, 20, 30, 43, 63).

18. Method for encapsulating an electronic component (3, 7, 36, 48) connected to a carrier (1, 4, 10, 20, 30, 43, 63) as claimed in any of the claims 1 - 11, by means of the processing steps of:
A) providing a carrier (1, 4, 10, 20, 30, 43, 63) with an electronic component (3, 7, 36, 48) placed at least partially in a recess (2, 5, 22, 47) in the carrier (1, 4, 10, 20, 30, 43, 63) and connected to the carrier (1, 4, 10, 20, 30, 43, 63),
B) feeding encapsulant (31, 33, 46, 64) to the recess (2, 5, 22, 47) in the carrier (1, 4, 10, 20, 30, 43, 63), and
C) connecting the encapsulant (31, 33, 46, 64) to the carrier (1, 4, 10, 20, 30, 43, 63) and the electronic component (3, 7, 36, 48).

19. Method as claimed in claim 18, **characterized in that** the encapsulant (31, 33, 46, 64) is fed in liquid form to the recess (2, 5, 22, 47) in the carrier (1, 4, 10, 20, 30, 43, 63) during processing step B) and cured during processing step C).

20. Method as claimed in claim 18 or 19, **characterized in that** the encapsulant (31, 33, 46, 64) placed in the recess (2, 5, 22, 47) is contacted by a mould part at least during processing step C).

21. Method as claimed in claim 20, **characterized in that** the recess (2, 5, 22, 47) in the carrier (1, 4, 10, 20, 30, 43, 63) with the electronic component (3, 7, 36, 48) placed therein is closed by a substantially flat mould part (42).

22. Method as claimed in any of the claims 18-21, **characterized in that** during processing step C) the carrier (1, 4, 10, 20, 30, 43, 63) is positioned in stationary manner relative to a holder part (41) engaging the carrier (1, 4, 10, 20, 30, 43, 63), and the encapsulant (31, 33, 46, 64) is contacted by a substantially flat plate (42) which is displaceable relative to the holder part (41).

23. Method as claimed in any of the claims 20-24, **characterized in that** during processing step C) the carrier (1, 4, 10, 20, 30, 43, 63) is displaced by a movable holder part (42) engaging on the carrier (1, 4, 10, 20, 30, 43, 63), and is contacted by a mould part advancing parallel to the carrier (1, 4, 10, 20, 30, 43, 63).

24. Method as claimed in any of the claims 18-23, **characterized in that** a plurality of electronic components (3, 7, 36, 48) placed in a single recess (2, 5, 22, 47) in the carrier (1, 4, 10, 20, 30, 43, 63) and connected to the carrier (1, 4, 10, 20, 30, 43, 63) are encapsulated simultaneously.

25. Method as claimed in any of the claims 18-24, **characterized in that** encapsulant (31, 33, 46, 64) is fed simultaneously to a plurality of recesses (2, 5, 22, 47) in the carrier (1, 4, 10, 20, 30, 43, 63).

26. Method for separating from a carrier (1, 4, 10, 20, 30, 43, 63) as claimed in any of the claims 1 - 11 an electronic component (3, 7, 36, 48) mounted on the carrier (1, 4, 10, 20, 30, 43, 63), comprising the processing steps of:
X) providing a carrier (1, 4, 10, 20, 30, 43, 63) provided with a recess (2, 5, 22, 47) which is at least partially filled with cured encapsulant (31, 33, 46, 64) and in which an electronic component (3, 7, 36, 48) is at least partially located, and
Y) separating a part of the carrier (1, 4, 10, 20, 30, 43, 63) containing the encapsulated electronic component (3, 7, 36, 48) from the remaining part of the carrier (1, 4, 10, 20, 30, 43, 63).

27. Method as claimed in claim 26, **characterized in that** parts of the carrier (1, 4, 10, 20, 30, 43, 63) enclosing the recess (2, 5, 22, 47) are also separated during the separation according to processing step Y).

28. Method as claimed in claim 26 or 27, **characterized in that** the separation according to processing step Y) takes place by means of a machining operation.