

Method, foil, mould part and surface layer for encapsulating electronic components mounted on a carrier using expansion spaces absorbing local foil layer displacements

5 The invention relates to a method for encapsulating electronic components mounted on a carrier. The invention also relates to a foil and a mould part for encapsulating electronic components according the method of the invention. Furthermore the invention relates to a surface layer for detachable connection to a metal mould part basis.

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The encapsulation of electronic components mounted on a carrier with an encapsulating material is a known art. On an industrial scale such electronic components are provided with an encapsulation, usually an encapsulation of a curing epoxy to which a filler material is added. There is a trend in the market
15 toward simultaneous encapsulation of larger quantities of relatively small electronic components. Electronic components may be envisaged here such as semiconductors (chips, although LEDs are in this respect also deemed semiconductors) which are generally becoming increasingly smaller. Once the encapsulating material has been arranged the collectively encapsulated electronic
20 components are situated in an encapsulation (package) which is arranged on one but sometimes also two sides of the carrier. The encapsulating material often takes the form of a flat layer connected to the carrier, but also alternative embodied encapsulations may be moulded dependent on the components to be moulded and their application. The carrier may consist of a lead frame, a multi-layer carrier -
25 manufactured partially from epoxy - (also referred to as board or substrate and so on) or another carrier structure.

During the encapsulation of electronic components mounted on a carrier, use is usually made according to the prior art of encapsulating presses provided with two
30 mould halves, into at least one of which is recessed one or plural mould cavities. After placing the carrier with the electronic components for encapsulating between the mould halves, the mould halves may be moved towards each other, e.g. such that they clamp the carrier. A, normally heated, liquid encapsulating material may then be fed to the mould cavities, usually by means of transfer moulding. As an
35 alternative it is also possible to bring the encapsulating material before closure of

the mould parts, e.g. as a granulate, in the mould cavity after which the components to be moulded are pressed into the encapsulating material; such compression encapsulating process is an alternative for transfer moulding. Applied as encapsulating material is epoxy (also referred to as resin) which is generally provided with filler material. After at least partial (chemical) curing of the encapsulating material in the mould cavity/cavities, the carrier with encapsulated electronic components is taken out of the encapsulating press. And the encapsulated products may be separated from each other during further processing. Foil may be used during the encapsulating process to screen or cover a part of the electronic components that have to stay free of encapsulating material and so to prevent parts of the electronic components to be covered by the encapsulating material. Foil may also or alternatively also be used to screen the encapsulating material from a mould surface. The partial covered products (not completely moulded or "over moulded" products are also referred to as "bare die" or "exposed die" products) may be used in various applications; like for instance various types of sensor components, ultra-low packages or heat dissipating components. This method of encapsulation is practised on large industrial scale and enables well controlled encapsulation of partially uncovered electronic components.

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A problem during the encapsulating process and the subsequent processing of the moulded electronic components is that the contact of the foil and the electronic components leads to varying local foil deformation with local lateral foil material displacement. Such lateral foil material displacement may lead to undesired variations in the dimensions of the encapsulation material after moulding. Inaccuracy in the dimensions of the moulded product is not allowed to meet the increasing dimension accuracy demands of moulded electronic components in the market.

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30 The present invention has for its object to provide an alternative method and means with which the advantages of the prior art encapsulating of electronic components are maintained but that enables more accurate dimension controlled encapsulation of electronic components.

The invention provides for this purpose a method for encapsulating electronic components mounted on a carrier comprising the processing steps of: A) at least partially covering with a foil layer a contact side of a mould part, the covered part of the contact side of the mould part including at least one recessed mould cavity; B)

5 placing the carrier with electronic components between at least two mould parts of a mould of which at least one of the mould parts is at least partially covered with the foil layer; C) moving the mould parts towards each other and clamping the carrier with electronic components between the contact sides of the mould parts, such that the foil layer is pressed onto the electronic components mould parts and

10 the at least one mould cavity is enclosing the electronic components to be encapsulated; D) bringing an encapsulating material in the mould cavity; and E) moving the mould parts apart from each other, and removing the carrier with moulded electronic components from the mould parts, wherein the foil layer facing the electronic components is impermeable for the moulding material and wherein

15 local foil layer displacement, due to the foil layer exerting local pressure onto the electronic components, at least partially is absorbed by foil layer expansion spaces. Local foil material displacement (downward or lateral foil material displacement) before and during the moulding process may result from uneven pressure load distribution over the surface of the foil layer. One of the reasons for such foil material

20 displacement may result from the fact that where the foil is pressed onto the electronic components the foil is (limited) compressed due to the local higher pressure exerted from opposite sides onto the foil. A further reason for foil material displacement may be irregularities that occur in the dimensions of the distance (height) of the electronic components protruding from the carrier and/or variations

25 in the dimensions of the carrier. The variations in dimensions of mounted electronic components and carrier may result in (limited) height variations over the surfaces of the electronic components the foil contacts that will also effect differences in local pressures exerted onto the foil.

30 As a result at some locations foil material may bulge (alternative wording: to pop out or to protrude) along the sides of the areas (surfaces) where the foil contacts the electronic components. Such bulging foil material may effect undesired local dips and thus measure differences (variations) in the moulded material part of the moulded electronic components. This "bulging effect" of pressure initiated lateral

35 foil material displacement may be prevented (or limited) with the method according

the invention as the expansion spaces will absorb any lateral foil material displacement and thus the bulging foil material will be prevented (or limited).

Besides the bulge absorbing effect of the expansion spaces a further positive effect they may level the pressure exerted on a mould part (the die) during moulding.

- 5 According the prior art and dependent on for instance dimensions of electronic components, mould cavities, mould parts, clamping forces and/or moulding material pressure gradients may occur on a mould part, which pressure gradients may influence the accuracy of the moulding process. The occurrence of pressure gradients during the moulding process may be mitigated with the present invention
- 10 as the expansion spaces may absorb any (lateral) foil material displacement and thus pressure gradients may be prevented (or limited). As a result the dimensions of the moulded electronic components may better be controlled.

- The local foil layer displacement may be absorbed by foil layer expansion spaces
- 15 that may for this purpose be provided in the foil and/or a contact side of a mould part. The expansions spaces have to be "compressible" thus they may be filled with gas, filled with a porous material or filled with any other material that is to be compressed at lesser load than the load that effects foil material displacement. The compressibility of the expansion spaces could hereby relate to the "softness" of the
- 20 material it comprises. The "softness" is hereby preferably attained through a sufficiently low compressive modulus (also known as "bulk modulus"). It is on the other hand preferred that the indentation hardness of the material is high enough to prevent flowing of the material as a result of plastic deformation.

- 25 In case the expansions spaces are gas-filled, the expansion spaces may be open but as an alternative or additionally expansion spaces may also be closed off, so embedded in the foil material. In a situation the expansion spaces are open they may be opened to the side of the foil that is opposite to the side of the foil that contacts the moulding material. The expansion spaces may hereby be closed off at
- 30 least during enclosure of the electronic components by the at least one mould cavity such that the gas is contained and compressed inside the expansion spaces by which the gas is enclosed. As an alternative, the expansion spaces may also be opened to the side of the foil that contacts the moulding material. In the situation that the expansion spaces are open to the side of the foil that contacts the

moulding material the foil material may be attached to the epoxy during moulding; e.g. by making use of conical apertures.

In a further alternative method the local foil layer displacement may be absorbed by
5 a laminated foil layer with a surface layer facing the electronic components that is impermeable for the moulding material and a support layer including expansion spaces. With such layered or laminated foil material the various functions the foil has to provide (moulding material impermeable covering and local foil layer displacement are divided over the various lamination layers and the various
10 functions are thus easier to optimise.

As an alternative (or additional) the local foil layer displacement may be absorbed by foil layer expansion spaces provided in a surface layer of the foil contacting side of a mould part. Such surface layer of the foil contacting side of a mould part may
15 be detachable connected to a metal mould part. The surface layer of the foil contacting side of a mould part may additionally be formed by a soft material surface layer, for which the soft material typically has a lower compressive modulus than the metal mould part. As an alternative the foil expansion spaces may be provided in a metal layer of the mould part or in an insert layer to be part of a mould
20 part. This alternative allows the use of prior art foil material as the functionality of the absorption of local foil layer displacement is provided by the surface layer of the mould part. Furthermore, as the surface layer of the mould part is shielded from the moulding material by the foil layer, the surface layer of the mould part may be used plural moulding cycles and this alternative will thus likely lead to limitation of the
25 variable moulding costs. A further advantage is that it enables the use of thinner (thus cheaper) foils.

The local foil layer displacement may be absorbed by expansion spaces that are homogeneous distributed. In this respect reference is made to a homogeneous
30 distribution of the expansion spaces over the foil and/or homogeneous distributed over the surface layer of the foil contacting side of a mould part. However the local foil layer displacement may alternatively be absorbed by expansion spaces that are irregularly distributed over the foil and/or homogeneous distributed over the surface layer of the foil contacting side of a mould part. In such irregular distribution the
35 number and or size of the expansion spaces may be distributed uneven / grouped

dependent on for instance the mould cavity location(s) and/or the locations of the electronic components. As an example the expansion space density may be larger at the locations there where the foil contacts the electronic components than there where the foil doesn't contact contacts the electronic components, resulting in more
5 dimension variation absorption at location where it is require or in the amount that the absorption is expected to be required. A further option is to limit the expansion space density there where an electronic components requires more pressure during moulding, e.g. at locations where an semiconductors are supported by bump contacts. Also other variations in expansion space distribution are possible; e.g.
10 related to the distance to the gate openings (feed to the mould cavities) or tuned to flash influencing mould tolerances.

The present invention also provides a foil for encapsulating electronic components mounted on a carrier with the method according the invention and as described
15 above, wherein the foil is provided with expansion spaces and a contact surface of the foil layer facing the electronic components is impermeable for the moulding material. As already explained in relation to the method for encapsulating electronic components according the present invention, the foil layer expansion spaces may be formed by a plurality of gas-filled holes. The expansion spaces may further be
20 open and/or closed off and the expansion spaces may be gas filled or filled with any other compressible material. Also the foil may be multi-layered with the expansion spaces in a layer that is separate from the layer that is configured to contact the electronic components and the moulding material during molding. Also the expansion spaces may be homogeneous distributed over the foil or irregularly
25 distributed as explained above. All features and advantages of the various alternatives of the foil using moulding method as disclosed above are incorporated here as well in relation to the foil for encapsulating electronic components according the present invention.

30 The present invention also provides a mould part for encapsulating electronic components mounted on a carrier with the method according the invention, wherein the contact side of the mould part facing the foil layer during molding is provided with foil layer expansion spaces. As already explained in relation to the method for encapsulating electronic components according the present invention, the foil layer
35 expansion spaces may hereby be formed by a plurality of gas-filled holes. The

contact side of the mould part may comprise a surface layer that is detachable connected to a metal mould part basis and which surface layer is provided with foil layer expansion spaces. This surface layer may furthermore be formed by a soft material. The soft material hereby typically has a lower compressive modulus than the metal mould part basis. Also here the expansion spaces (now in the surface layer) may be homogeneous distributed or irregularly distributed. All features and advantages of the various alternatives of the foil using moulding method as disclosed above are incorporated here as well in relation to the mould part according the present invention.

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Finally the invention also provides surface layer formed by a soft material for detachable connection to a metal mould part basis as part of the mould part according the invention as described above, wherein the surface layer is provided with foil layer expansion spaces that may be homogeneous distributed or irregularly distributed. Again, all features and advantages of the various alternatives of the foil using moulding method as disclosed above are incorporated here as well in relation to the mould part according the present invention.

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The present invention will be further elucidated on the basis of the following non-limitative clauses:

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1. Method for encapsulating electronic components mounted on a carrier comprising the processing steps of:
 - A) at least partially covering with a foil layer a contact side of a mould part, the covered part of the contact side of the mould part including at least one recessed mould cavity;
 - B) placing the carrier with electronic components between at least two mould parts of a mould of which at least one of the mould parts is at least partially covered with the foil layer;
 - C) moving the mould parts towards each other and clamping the carrier with electronic components between the contact sides of the mould parts, such that the foil layer is pressed onto the electronic components mould parts and the at least one mould cavity is enclosing the electronic components to be encapsulated;
 - D) bringing an encapsulating material in the mould cavity; and

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E) moving the mould parts apart from each other, and removing the carrier with moulded electronic components from the mould parts,

5 wherein the foil layer facing the electronic components is impermeable for the moulding material and wherein local foil layer displacement, due to the foil layer exerting local pressure onto the electronic components, at least partially is absorbed by foil layer expansion spaces.

10 2. Method for encapsulating electronic components according to clause 1, **characterised in that** local foil layer displacement is absorbed by foil layer expansion spaces that are provided in the foil.

15 3. Method for encapsulating electronic components according to clause 1, **characterised in that** local foil layer displacement is absorbed by a laminated foil layer with a surface layer facing the electronic components that is impermeable for the moulding material and a support layer including expansion spaces.

20 4. Method for encapsulating electronic components according to any of the foregoing clauses, **characterised in that** local foil layer displacement is absorbed by foil layer expansion spaces provided in a surface layer of the foil contacting side of a mould part.

25 5. Method for encapsulating electronic components according to clause 4, **characterised in that** local foil layer displacement is absorbed by the surface layer of the foil contacting side of a mould part formed by a soft material surface layer detachable connected to a metal mould part.

30 6. Method for encapsulating electronic components as claimed in any of the foregoing clauses, **characterised in that** local foil layer displacement is absorbed by expansion spaces that are homogeneously distributed.

35 7. Method for encapsulating electronic components as claimed in any of the clauses 1 - 5, **characterised in that** local foil layer displacement is absorbed by expansion spaces that are irregularly distributed.

8. Method for encapsulating electronic components as claimed in clause 7,
characterised in that the expansion spaces density is larger there where the foil
contacts the electronic components than there where the foil doesn't contact
5 contacts the electronic components.
9. Foil for encapsulating electronic components mounted on a carrier with the
method according any of the foregoing clauses, wherein the foil is provided with
expansion spaces and a contact surface of the foil layer facing the electronic
10 components is impermeable for the moulding material.
10. Foil for encapsulating electronic components according clause 9,
characterised in that the expansion spaces are closed off.
- 15 11. Foil for encapsulating electronic components according clause 9 or 10,
characterised in that the foil layer is laminated, comprising a surface layer facing
the electronic components that is impermeable for the moulding material, and a
support layer including expansion spaces.
- 20 12. Mould part for encapsulating electronic components mounted on a carrier
with the method according any of the clauses 1 - 8, wherein the contact side of the
mould part facing the foil layer is provided with foil layer expansion spaces.
- 25 13. Mould part for encapsulating electronic components mounted on a carrier
according clause 12, **characterised in that** the foil contacting side of the mould
part comprises a surface layer formed by a soft material that is detachable
connected to a metal mould part basis and which surface layer is provided with foil
layer expansion spaces.
- 30 14. Mould part for encapsulating electronic components according clause 13,
characterised in that the expansion spaces in the surface layer are irregularly and
mould cavity location related distributed.

15. Mould part for encapsulating electronic components according any of the clauses 12 - 14, **characterised in that** the expansion spaces in the surface layer are irregularly and electronic components location related distributed.

- 5 16. Surface layer formed by a soft material for detachable connection to a metal mould part basis as part of the mould part claimed in any of the clauses 13 – 15, wherein the surface layer is provided with foil layer expansion spaces.

The present invention will be further elucidated on the basis of the non-limitative
10 exemplary embodiments shown in the following figures. Herein shows:

- figure 1 a side-view on a cross-section through a mould for encapsulating electronic components mounted on a carrier according the prior art;
figure 2 a detailed view of the cross-section through the mould of figure 1;
15 figure 3 a detailed view of a cross-section through a mould for encapsulating electronic components mounted on a carrier according the present invention;
figures 4A – 4C various alternative embodiments of the foil according the present invention; and
20 figures 5A and 5B detailed views of the cross-section through a mould part for encapsulating electronic components according the present invention.

Figure 1 shows a cross-section through a mould 1 for encapsulating electronic components 2 mounted on a carrier 3. The mould 1 comprises two mould parts; a
25 top mould part 4 and a bottom mould part 5 which are displaceable relative to each other. In the situation depicted in figure 1 the mould parts 4, 5 are moved towards each other such that they are clamping the carrier 3 with electronic components 2 in between the mould parts 4, 5. In the top mould part 4 mould cavity 6 is recessed wherein that receives the electronic components 2. Against the contact side of the
30 top mould 4 a foil layer 7 is placed which has a function to enable enhanced release of moulded electronic components 2 but also to keep the top side of the electronic components 2 free of moulding material 8. The moulding material 8 is brought in between the mould parts 4, 5, especially in the spare rooms in the mould cavity 6 (which are the locations in between - and optionally under - the electronic
35 components 2).

Figure 2 shows a detailed view of the cross-section through the mould 1 of figure 1 with a part of the top mould 4 and a part of the bottom mould 5 clamping the carrier 3, an electronic component 2 and the foil layer 7. As the pressure on the foil layer 7 above the electronic component 2 is higher than there were the moulding material 8 is being allocated, a limited amount of material the foil layer 7 above the electronic component 2 will be pushed aside (according the arrows P_1). The result of material of the foil layer 7 pushed side wards (laterally) is that bulges 9 (bumps) may occur in the foil material 7 on locations adjoining the electronic component 2. The result is that the moulding material 8 will show dimples 10 at the locations corresponding with the bulges 9 in the foil material 8. These dimples 10 (or grooves/slots/pits) result undesired dimension inaccuracies of the moulded electronic components 2.

Figure 3 shows a detailed view of the cross-section through the mould 1 of figure 1 however now in combination with a foil material 11 according the present invention. Also here the top mould 4 and a part of the bottom mould 5 clamp the carrier 3, an electronic component 2 and the foil layer 11. And as seen in figure 2 also here the pressure on the foil layer 11 above the electronic component 2 is higher than there were moulding material 12 is being allocated. However the foil material 11 is provided with foil layer expansion spaces 13 that enable the absorption of material of the foil layer 11 above the electronic component 2 that is pushed aside. The expansion spaces 13' above the electronic component 2 are smaller than the expansion spaces 13 aside the electronic component 2 as the expansion spaces 13' above the electronic component 2 are absorbing local foil layer displacements and as a result their size is reduced. As a result there is no material of the foil layer 11 pushed side wards of the electronic component 2 resulting in absence of prior art bulges as shown in figure 2. The moulding material 12 due to the use of foil layer 11 has a more flat upper surface than in the prior art situation depicted in figure 2.

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Figure 4A shows a foil 20 for encapsulating electronic components that is formed a single layer soft film with a moulding material impermeable contact surface 21 for facing the electronic components and moulding material. On the opposite side 22 of the impermeable contact surface 21 open expansion spaces 23 (holes) are homogeneous distributed and provided for absorption of local foil layer expansion.

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Figure 4B shows a foil 25 for encapsulating electronic components that is formed a two material layers 26, 27. A harder moulding material impermeable contact layer 26 is combined here with a softer layer 27 with homogeneous (uniform) distributed open expansion spaces 28 (holes).

Figure 4C shows a foil 30 for encapsulating electronic components that is formed a two material layers 31, 32. A moulding material impermeable contact layer 31 is combined here with a support layer 32 with irregular distributed open expansion spaces 33 (holes). The expansion spaces 33 may for instance be provided at those locations where the foil 30 will contact the electronic components to be moulded.

Figure 5A shows a top mould part 40 for encapsulating electronic components 41 mounted on a carrier 42 with a contact side 43 of the top mould part 40 facing the electronic components 41 is provided with a softer support layer 44 that is attached to a metal mould part basis 45. In the top mould support layer 44 expansion spaces 46 are provided for local expansion of a foil layer 47 that is located in between the mould support layer 44 and the electronic components 41. In the situation as depicted in figure 5A the mould part 40 is not yet exerting pressure onto the electronic component 41.

The top mould part 40 as shown in figure 5A is also depicted in figure 5B, however now in a position wherein the mould part 40 exerts pressure onto the electronic component 41. As a result of the compensation of local pressure onto the top mould support layer 44 the expansion spaces 46' are now smaller than before the pressure exertion started. As the expansion spaces 46' "absorb" the there is no material of the foil 47 pushed side wards (laterally) so prior art bulges as shown in figure 2 will not (or less) appear. Only a minor height difference may appear of the contact surface of the foil 47 at the location where it faces the electronic component 41 and threw locations where the surface of the foil 47 is not facing the electronic component.