A CHIP MODULE AND PROCESS FOR THE PRODUCTION THEREOF

The present invention relates to a chip module comprising a substrate and at least one chip arranged on the substrate according to the preamble of Claim 1. The present invention further relates to a process for the production of a chip module according to the preamble of Claim 7.

Chip modules comprising a chip arranged on a substrate are basically used in all cases in which simplified electric contacting of the chip is to be facilitated by means of substrate connecting leads which are substantially larger than the chip terminal surfaces. Thus such chip modules are used, for example, in chip cards and via the exposed substrate connecting leads extending over the card surface permit "external contacting" of the chip accommodated inside the chip card by the arrangement on the rear side of the substrate. Such chip modules are also used to construct so-called contactless chip cards in the case of which the substrate connecting leads provide for simplified contacting with an antenna coil arranged inside the card body. Naturally such chip modules can also be used, for example, to construct a so-called "combi-card" in the case of which external contacting for contact access to the card chip as well as internal contacting for contactless access to the chip via the antenna coil are facilitated by means of the substrate.

The combination of a chip with the substrate to form the chip module results in a composite structure, the thickness of which is relatively great compared to the thickness of the chip and the thickness of the substrate and which must be accommodated in a card body with defined outer dimensions. To ensure that the accommodation of a chip module in a card body imposes the least possible restrictions upon the possibilities of further component installations in the card body, it thus proves essential for the chip module to be designed to be as thin as possible.

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A disadvantage of the known, relatively thick chip modules is that simply by virtue of their relative thickness, they have greater bending resistance compared to the flexible card body and therefore when the card body is subjected to bending stress as frequently occurs in everyday use, in particular when the substrate is arranged in the card surface as in the case of a contact card, the connection between chip module and card body can be stressed to a high level, leading to the detachment of the chip module from the card body.

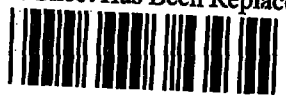
The object of the present invention is to propose a chip module which is characterised by an overall planar formation.

This object is achieved by means of a chip module having the features of Claim 1.

In the chip module according to the invention, by means of terminal surfaces arranged on its front side the chip is contacted onto contact surfaces of the substrate, and as a result of a removal of material on the surface of its rear side the chip has a thickness reduced compared to its original thickness.

The chip module according to the invention utilizes the fact that the electric circuit planes in the silicon body of the chip are adjacent to the front- or contact side of the chip provided with the terminal surfaces, and the region of the silicon body adjoining the surface of the rear side is free of electric circuit planes. It is thus possible, without impairing the function of the chip, to remove the surface of the chip from the rear side until a minimum thickness of the chip body ensuring satisfactory chip functioning is obtained, and in this way to make the chip substantially thinner.

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The reduction in thickness of the chip not only facilitates a corresponding reduction in the overall thickness of the chip module but also enables the bending behaviour of the chip module to be influenced. As a result of the reduction in the chip thickness, the bending behaviour of the chip is adapted to the bending behaviour of the substrate, thus leading to an overall more readily bending, more flexible chip module, the bending behaviour of which more or less resembles that of the card body.

In a preferred embodiment of the chip module, in order to achieve an interlocking contacting with bonding pads formed on the terminal surfaces, the chip projects into recesses of the substrate whose base is formed by the conductor path structure. The engagement of the bonding pads in the recesses of the substrate leads to a connection between chip and substrate with particularly good shearing strength. Furthermore, due to this "sunken" arrangement of the bonding pads in the substrate, a particularly planar design of the chip module is achieved simply by virtue of its configuration.

The bonding pads can be formed from any electrically conductive material, such as for example an electrically conductive adhesive or a contact metallization made of solder material or the like.

It is particularly advantageous for the chip bonding pads to be embedded in an electrically conductive connecting material arranged in the recesses of the substrate. By means of this embedding of the bonding pads in the connecting material it is also easily possible to compensate for any tolerances occurring in the difference between the height of the bonding pads and the depth of the recesses through the connecting material and, while retaining a reliable, electrically conductive connection between the bonding pads of the chip and the connecting

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leads of the substrate, to provide the flattest possible overall arrangement of chip and substrate wherein the surface of the chip and the surface of the substrate can adjoin one another directly, thus without a gap. In the production of the chip module according to the invention it is thus also possible to omit the application of an underfiller known in the context of underfiller technology. The mechanically stabilising effect of the underfiller which improves the shearing strength of the chip module can also be dispensed with since a particularly stable, mechanical load-bearing connection is provided by the "embedding" of the bonding pads and the associated covering of the bonding pads with the connecting material on all sides, at least in partial regions of the contact metallizations.

The above described form of interlocking contacting between a chip and a substrate also has substantial advantages regardless of whether the contacted chip is a chip reduced in thickness by the removal of material or is a conventional chip, especially when a mechanically stable chip module is to be constructed.

To further increase the mechanical stability of the connection provided between chip and substrate in the chip module, at least one further projection which is electrically independent of the chip structure can be provided on the chip surface in addition to the bonding pads electrically conductively connected to the chip structure, said projection engaging into a fixing recess of the substrate. This projection, which can be designed and produced to be identical to the bonding pads forming electric terminals, provides a "contact dummy" which has merely a mechanically stabilizing function.

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If desired, further mechanical stabilisation or sealing can be provided by a peripheral or planar application of adhesive.

A particularly advantageous use of the chip module is in a chip card.

In the process according to the invention for the production of a chip module of the type explained in the foregoing, a handling unit, comprising at least one chip and a substrate and constituting, as it were, an intermediate product in the manufacture of the final chip module, is firstly formed by contacting the chip or chips onto the substrate provided with a conductor path structure, such that the chip or chips is/are contacted by its/their terminal surfaces onto contact surfaces of the substrate and then the chip or chips is/are processed on its/their rear side by a material-removing process, where the substrate provides for the handling and stabilisation of the chip(s) during the processing.

Prior to the contacting of the terminal surfaces, selective cleaning can take place of the chip terminal surfaces to be contacted and/or of the substrate contact surfaces or the bonding pads or connecting material surfaces optionally applied thereto.

In the implementation of the process according to the invention, in addition to its original specified function of enlarging the terminal surfaces for subsequent contacting, the substrate also acquires the function of an accommodating device which accommodates the chip during the processing. It is only this function which facilitates the easy handling of the chips during the processing of the chips arranged individually on the substrate and thus previously separated from a wafer composite.

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In accordance with an advantageous variant of the process according to the invention, the handling unit is formed in that a plurality of chips are contacted onto a continuously formed substrate strip and the substrate strip is separated to form individual chip modules following the processing of the individual chips. This enables the substrate strip to be continuously equipped with chips and facilitates the subsequent continuous processing of the individual chips to form the chip modules of reduced thickness, so that the chip modules of reduced thickness can also be produced in a particularly economical manner.

In the implementation of the above mentioned process variant, a plurality of chips can be processed simultaneously. The chips can be processed using a tool which permits the simultaneous processing of a plurality of chips or the chips can be processed simultaneously using different tools.

For the formation of the handling unit it has proved particularly advantageous to carry out the contacting of the chip or chips on the substrate in such manner that bonding pads arranged on the terminal surfaces of the chip or chips are inserted into a connecting material arranged in recesses of the substrate. In this way a connection can be obtained which withstands even the highest levels of shearing stress, such as occur for example during the grinding processing of the rear side of the chip, as the connection established by the embedding of the bonding pads into the connecting material is additionally secured by the engagement of the bonding pads into the recesses of the substrate.

The processing of the chip or chips can be performed using a grinding or lapping process. Another possible method of processing the chips to form a chip module of reduced

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thickness consists of performing a chemical etching process on the rear side of the chip.

The connecting material required to form the connection can differ in type and form. Thus, for example, prior to the insertion of the bonding pads into the recesses, the connecting material can be introduced into the recesses by planar application to the surface of the insulating layer and subsequent stripping off of the surface.

It is also possible to introduce the connecting material into the recesses in a liquid state, before or after the insertion of the bonding pads into the recesses, in a dosing process.

Another possible method of applying the connecting material consists of introducing the connecting material into the recesses in lump form, for example lead/tin solder spheres, prior to the insertion of the bonding pads.

The substrate used to produce the chip module can also have been pre-prepared inasmuch as the bonding pads are inserted into recesses already provided with a coating of connecting material in the region of the connecting leads. It is thus possible for the process according to the invention for the production of a chip module also to be performed on the basis of substrates appropriately pre-prepared by the substrate manufacturer, thereby facilitating a particularly cost-effective implementation of the process.

If the connection between the connecting material and the bonding pads and between the connecting material and the connecting leads takes place under the influence of pressure and heat, a connection between chip and substrate is ensured in which the adjacent surfaces of chip and substrate bear against one another whereby, when an appropriate quantity of connecting material is provided, an

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at least partial embedding of the bonding pads into the connecting material occurs, even in the case of a connecting material with high boundary surface tension.

The connection between the connecting material and the bonding pads can be implemented in accordance with the known flip-chip method in which the bonding pads of the chip are pressed against the connecting material under thermal influence. The heating of the connecting material necessary for the establishment of the connection thus takes place during the placement.

However, the connection can also be implemented such that only after the placement does the heating of the connecting material and the establishment of the connection take place in a so-called reflow process.

Irrespectively of the time at which the heat is introduced into the connecting material, it has proved particularly advantageous for the introduction of the heat into the connecting material to take place via the connecting leads of the substrate. In this way the chip remains substantially free of thermal stress during the establishment of the connection.

It is also advantageous if a function test of the chip is performed following the processing of the chip. Here the connecting leads of the substrate form the test contacts. The implementation of this electric test, generally a continuity test, facilitates the detection of a chip module which has been functionally impaired, possibly due to the processing of the chip or due to the formation of the connection between chip and substrate.

In the following the chip module according to the invention will be explained in detail in the form of an exemplary

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embodiment and a process for its production, making reference to the drawings in which:

Figure 1 is a perspective view of a chip module comprising a chip and a substrate arranged thereon;

Figure 2 is an enlarged side view of the chip module illustrated in Figure 1;

Figure 3 is an enlarged partial view of the chip module according to Figure 2;

Figure 4 is a view corresponding to Figure 3 directly prior to the connection of the chip to the substrate to form the chip module;

Figure 5 is a schematic diagram of a device for the continuous production of the chip module shown in Figure 1;

Figure 6 is a partial view of a substrate strip with individual substrates.

Figure 1 illustrates a chip module 10 comprising a chip 11 and a substrate 12 contacted thereto. On the upper side, facing away from the chip 11, of an insulating layer here in the form of a carrier layer 13, the substrate 12 comprises connecting leads 14, 15 which in the example shown here are provided in duplicate, extending upon and substantially longitudinally over the carrier layer 13.

In the exemplary embodiment shown in Figure 1, the chip 11 comprises two raised contact metallizations 16, 17, referred to in the literature of the art as "bumps", which penetrate through and project from a passivation layer 18 (Fig. 3) of the chip 11 not shown in detail in Figure 1.

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Although Figure 1 illustrates a chip 11 provided only with two contact metallizations 16, 17, as used for example in a chip card (not shown in detail here), it is to be emphasised that the following details apply equally to chips having a different number of contact metallizations, in particular those having a plurality of contact metallizations, in which case the substrate to be connected to such a chip is designed correspondingly with a larger number of connecting leads. The design shown in Figure 1 has been selected on account of the particularly clear representation with which it is associated.

In the case of the chip module 10 shown in Figure 1, the chip 11 contacted onto the substrate 12 has a regular thickness D which substantially corresponds to the thickness of a wafer, not shown in detail here, from which the chip 11 has been formed by separation from the wafer composite. As will be explained further in the following, the configuration of the chip module 10 shown in Figure 1 forms a handling unit as basis of the production of a chip module 37, illustrated by way of example in Figure 2, comprising the chip 38 of reduced thickness. As is to be indicated by the shaded subsidiary area in Figure 2, following the material-removing processing of a surface arranged opposite the contact metallizations 16, 17 and referred to in the following as rear side 39, the chip 38 is to possess a thickness reduced by Δd compared to the chip 11 shown in Figure 1, so that the thickness d of the chip 38 is substantially smaller than the thickness D of the chip 11 (Figure 1).

If Figure 2 is compared with Figure 3, which illustrates an enlarged partial view of the chip module 10, it will be apparent that the thickness reduction Δd shown in Figure 2 results in a chip module 37 with a substantially smaller overall thickness h compared to the chip module 10 with the overall thickness H.

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In the form of the example of a connection point, Figures 3 and 4 illustrate the manner in which the connection between the contact metallization 17 and the connecting lead 15 of the substrate 12 is established to form the chip module 10. It can clearly be seen how, commencing from a covering layer with associated recess 19, the contact metallization 17 engages into the recess 19 formed in the carrier layer 13 in the region of the contact metallization 17. The recess 19 in the carrier layer 13 extends up to the connecting lead 15 arranged on the rear side of the carrier layer 13 facing towards the chip 11 and leaves said connecting lead 15 exposed in the region of a rear chip contact zone 21 arranged opposite an outer contact side 20.

The recess 19 contains a connecting material 22 which serves both to establish an electrically conductive connection between the contact metallization 17 and the chip contact region 21 of the connecting lead 15 and to establish a mechanically reliable connection between the chip 11 and the substrate 12.

The connecting material 22 illustrated in Figures 3 and 4 consists of a solder coating in solid form applied to the chip contact region 21 of the connecting lead 15. The solder composition selected for the solder coating here is adapted to the alloy or material composition used for the contact metallization 17. When gold is used for the contact metallization 17, a lead/tin solder is suitable as connecting material. In place of the solder coating it is also possible, for example, to use an electrically conductive epoxide-resin-based adhesive or a thermoplastic adhesive.

In any case, regardless of the nature of the connecting material, the connection illustrated in Figure 3 between the contact metallization 17 and the chip contact region 21 of the connecting lead 15 is established by the

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introduction (arrow 48 in Figure 4) of the contact metallization 17 into the recess 19, commencing with the chip 11 arranged above the substrate 12 (Figure 4), with the displacement of the connecting material 22. In order, in the case of a connection established in this way, to ensure a repeatable, uniform and smallest possible overall height H of the chip module 10 formed by the chip 11 and substrate 12, it is sufficient to introduce the contact metallization 17 into the recess 19 until the passivation layer 18 of the chip 11 bears against the surface of the carrier layer 13 facing towards the chip 11. To further improve the mechanical connection between the chip 11 and substrate 12 effected via the connecting material 22 and illustrated in Figure 1 in the case of the example of the contact metallization 17, as indicated in Figure 1 it is possible to provide further metallization projections 35, 36 in addition to the contact metallizations 16, 17 serving for the electrical contacting of the substrate 12, which further projections 35, 36 are formed similarly to the contact metallizations 16, 17 and are inserted into fixing recesses which correspond in form to the recesses 19 but have not been shown in detail here. Here again, precisely as in the case of the contact metallizations 16, 17, a connection is established between the metallization projections 35, 36 and the connecting leads 14, 15, although this connection serves merely for the mechanical fixing of the chip on the substrate and does not have any electrical contact function. To assist the adhesion of the chip 11 on the substrate 12, planar or peripheral adhesion of the chip 11 on the substrate 12 can also be provided.

As can be clearly seen from Figure 3, even in the case of the only partial recessing of the contact metallization 17 into the connecting material 22, wetting occurs of all the exposed sides of the contact metallization 17, here shown in simplified form as a parallelepiped. This leads to correspondingly small electrical resistances in the contact

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region of the contact metallization 17 and the connecting material 22 and to good mechanical adhesion.

In order to prevent the formation of pressure cushions due to compression effects in the recess 19, especially when the recess 19 is plentifully filled with connecting material 22, on its upper side facing towards the chip the carrier layer 13 of the substrate 12 can be provided with a groove-like ventilating channel 23 leading outwards from the recess 19 or with other suitable devices.

In addition to the insulating layer formed as carrier layer 13 and illustrated in Figure 1, a further insulating layer, which covers the connecting leads at least except for contact recesses, can also be arranged on said connecting leads. Additionally, the chip module 10 can also be provided with a coil arranged on the substrate to form a transponder.

The softening of the connecting material or melting of the connecting material required for the recessing of the contact metallization 17 into the connecting material 22 can take place simultaneously to the application of the pressure required for the displacement of the connecting material, as illustrated for example in Figure 5. Figure 5 shows a chip module production device 24 with two components combined in a stationary device, namely a chip placement device 25 and a heating device 26. As can be seen from Figure 5, the chip 11 is moved from above, with its contact metallizations 16, 17 facing downwards, towards the substrate 12 here arranged in a substrate strip 27. The contact metallizations 16, 17 are now brought to bear against the connecting material 22 arranged in the recesses 19 in the chip contact region 21 (Fig. 3) of the connecting leads 14, 15. During the contacting of the contact metallizations 16, 17 with the connecting material 22, contact heating of the connecting leads 14, 15 can be

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effected by means of the heating device 26, which is moved from below the substrate strip 27 towards the particular substrate 12. Under the pressure of the chip placement device 25, the contact metallizations 16, 17 then penetrate into the connecting material 22 softening under the effect of the heat.

As an alternative to heating the connecting material 22 during the placement of the chip 11 as described in the foregoing, it is also possible to melt the connecting material 22 in a reflow process following the placement of the chip 11, and thus to effect the wetting of the contact metallizations required for the connection of the connecting material 22 to the contact metallizations 16, 17. Depending upon the nature of the connecting material, here it can be necessary to overcome the boundary surface resistance of the connecting material 22 by applying pressure to the contact metallizations 16, 17 using an additional pressure device downstream of the chip placement device 25, in order to facilitate the recessing of the contact metallizations 16, 17 into the connecting material 22 so as to achieve the described embedding of the contact metallizations 16, 17 in the connecting material 22.

Figure 6 is a plan view of the substrate strip 27 already mentioned in association with the chip module production device 24 illustrated in Figure 5. As can be seen from the plan view, the substrate strip 27 comprises a plurality of continuously, consecutively formed substrates 12 connected to one another via their connecting leads 14, 15 extending over the substrates. In order to separate an individual substrate 11, as shown in Figure 1, from the substrate strip 27 it is only necessary to perform a punching process along the punching lines 47 represented in dash-dotted manner in Figure 5. The punching process serves to sever connecting regions 29, 30 of the connecting leads 14, 15 and outer edges 32, 33 of the substrate strip 27 which form

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traction edges and are provided with a perforation 31. Such a design of the substrate strip 27 facilitates the continuous production of chip modules 10 wherein, as illustrated in Figure 5, the substrate strip 27 with the substrates 12 provided therein is conducted past the chip placement device 25 in the feed direction 34 in clock-controlled manner.

The chip modules 10 produced in the chip module production device 24 in each case constitute an intermediate product or handling unit for the subsequent processing of the chips 11 with the goal of producing chip modules 37 comprising chips 38 which are thinner than the chips 11. By virtue of the composite formed by the substrate strip, the chip modules 10 in their totality form a corresponding handling composite. Prior to the separation of the chip modules 10 from the substrate strip 27 explained in the foregoing, as illustrated in Figure 5 in the example of a continuous production process, material-removing processing of the chips 11 of the chip modules 10 takes place following their production in the chip module production device 24. For this purpose the chip modules 10 are fed to a processing device 40 in which chip body material is removed from the rear side 39 of the chip 11, as schematically illustrated in Figure 2. In the processing operation illustrated by way of example in Figure 5, the processing device consists of a belt grinding device 40 comprising an endless grinding belt 43 continuously revolving via rollers 42 on a device carrier 41. The device carrier 41 is provided with an adjusting device, not shown in detail here, which enables the device carrier 41 to be moved upwards and downwards in the direction of the double arrow 44. By superimposing an adjusting movement, directed towards the rear side 39 of the chip 11, upon the revolving movement of the grinding belt 43, the chip 11 can be continuously reduced in its thickness until a chip 38 is obtained having a thickness d reduced compared to that of the original chip 11 (Figure

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2). The thickness d attainable by means of this processing is limited by the boundary layer 45, indicated in dash-dotted lines in Figure 2, which delimits a circuit region 46 of the chip situated between the passivation layer 18 and the boundary layer 45. Until the boundary layer 45 is reached, the chip can be processed from its rear side 39 without impairing the function of the chip due to penetration into the circuit region 46.

The processing of the chip 11 with the belt grinding device 40 as illustrated in Figure 5 gives rise to the chip module 37 illustrated in Figure 2, which has a substantially reduced overall height h compared to the starting chip module 10. The chip modules 37 of reduced thickness continuously produced in accordance with the process illustrated in Figure 5 can then be separated from the composite substrate strip 27 as described in the foregoing with reference to Figure 6.

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Claims

1. A chip module comprising a substrate and at least one chip arranged on the substrate, wherein the chip is contacted via terminal surfaces arranged on its front side onto connecting leads of the substrate provided with a conductor path structure, characterised in that the chip (38) has a thickness which is reduced compared to its original thickness as a result of a removal of material on its rear side (39).

2. A chip module according to Claim 1, characterised in that in order to obtain an interlocking contacting with bonding pads (16, 17) formed on the terminal surfaces, the chip (38) projects into recesses (19) of the substrate (12) whose base is formed by the connecting leads (14, 15) of the conductor path structure.

3. A chip module according to Claim 1 or 2, characterised in that the bonding pads (16, 17) of the chip (38) are embedded in an electrically conductive connecting material (22) which is arranged in the recesses (19) of the substrate (12).

4. A chip module according to Claim 2 or 3, characterised in that in addition to the bonding pads (16, 17), which are electrically conductively connected to the conductor path structure and engage into the recesses (19), at least one further projection (35, 36) which is electrically independent of the conductor path structure is provided on the front side of the chip (38), said projection (35, 36) engaging into a fixing recess of the substrate (12).

5. A chip module according to one or more of the preceding claims, characterised in that the chip (11,

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38) is adhesively connected to the substrate (12) in peripheral or planar manner.

6. A chip module according to one or more of the preceding claims, characterised by its use in a chip card.

7. A process for the production of a chip module comprising a substrate and at least one chip arranged on the substrate, characterised by the process steps:

- formation of a handling unit (10) consisting of at least one chip (11) and a substrate (12) by contacting the chip or chips on the substrate provided with a conductor path structure, in such manner that the chip or chips is/are contacted by its/their terminal surfaces onto connecting leads (14, 15) of the substrate and
- processing of the chip or chips (11) by means of a material removal process on its/their rear side (39), the substrate (12) providing for the handling and stabilisation of the chip or chips (11) during the processing.

8. A process according to Claim 7, characterised in that for the formation of the handling unit (10) a plurality of chips (11) are contacted onto a continuous substrate strip (27) and for the formation of individual chip modules (37) the substrate strip (27) is separated following the processing of the chip (11).

9. A process according to Claim 7 or 8, characterised in that the processing of a plurality of chips (11) is carried out simultaneously.

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10. A process according to one or more of Claims 7 or 9, characterised in that the processing of a plurality of chips (11) is carried out using a common tool.

11. A process according to one or more of Claims 7 to 10, characterised in that for the formation of the handling unit (10) the contacting of the chip or chips (11) onto the substrate (12, 27) takes place in such manner that bonding pads (16, 17) arranged on the terminal surfaces of the chip or chips (11) are inserted into a connecting material (22) arranged in recesses (19) of the substrate (12, 27).

12. A process according to one or more of Claims 7 to 11, characterised in that the processing of the chip or chips (11) is carried out by means of a grinding or lapping process.

13. A process according to one of Claims 7 to 11, characterised in that the processing of the chip or chips (11) is carried out by means of an etching process.

14. A process according to one or more of Claims 7 to 13, characterised in that a function test of the chip is carried out following the processing of the chip (11).

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