Method for Producing a Wafer Provided with Chips

~~Specification~~

This invention relates to a method for producing a product wafer which is provided with chips, especially on two sides~~, as claimed in Claim 1~~.

By far most of the wafers produced today are provided with chips or so-called dices only on one side. Wafers are equipped in mass production and at the same time there is the requirement of the industry to implement smaller and smaller structures. This also applies to the thickness of the wafer, especially for multilayer wafers which are repeatedly stacked.

The further optimum use of the available space leads to wafers being required which are provided with chips or dices which are more and more double-sided recently, therefore on both sides, and through silicon vias (TSVs) can enable electrical contacts between the front and back of the product wafer.

The greatest problem in the production of these double-sided wafers consists in handling during mass production, which can comprise different production steps, such as for example bonding, debonding, alignment, grinding, etching and many others. Stabilization of the large-area product wafer which generally has a diameter of 300 mm by a carrier wafer is necessary especially due to the thinning/back thinning of the product wafer which is provided in the production process.

Stabilization or support by a carrier wafer in wafers outfitted on one side is therefore

make the first side accessible to further process steps.

~~The object~~Embodiments of this invention ~~is to devise~~ disclose a method for producing a product wafer which is provided with chips especially on two sides, by which the product wafer can be reliably and carefully handled during the production process.

~~This object is achieved with the features of Claim 1. Advantageous developments of the invention are given in the dependent claims.~~

According to a first aspect of the present invention, there is provided a method for producing a product wafer, the method including steps of: bonding a first side of the product wafer to a first rigid carrier wafer with a first intermediate layer, the first intermediate layer including one first adhesion layer applied at least on the edge side of the first side of the product wafer, the first adhesion layer made of a first material, processing a second side of the product wafer opposite to the first side by application of chips to the second side, bonding the second side of the product wafer to a second rigid carrier wafer with a second intermediate layer, the second intermediate layer including: one second adhesion layer applied at least on the edge side of the second side of the product wafer, the second adhesion layer being made of a second material wherein the first adhesion layer and the second adhesion layer are made from different materials such that both rigid carrier wafers bonded to the product wafer can be separated selectively from the product wafer, after both the first rigid carrier wafer and the second rigid carrier wafer are bonded to the product wafer, applying a first force to the combination of the first rigid carrier wafer, the second rigid carrier wafer and the product wafer wherein the first rigid carrier wafer and the first intermediate layer are separated from the product wafer, and after the first rigid carrier wafer and the first intermediate layer are separated from the product wafer, applying a second force to the second rigid carrier wafer wherein the second rigid carrier wafer and the second intermediate layer are separated from the product wafer.

According to a second aspect of the present invention, there is provided a method for producing a product wafer, the method including steps of: bonding a first side of the product wafer to a first rigid

carrier wafer with a first intermediate layer, the first intermediate layer including one first adhesion layer applied at least on the edge side of the first side of the product wafer, the first adhesion layer made of a first material, processing a second side of the product wafer opposite to the first side by application of chips to the second side, bonding the second side of the product wafer to a second rigid carrier wafer with a second intermediate layer, the second intermediate layer including: one second adhesion layer applied at least on the edge side of the second side of the product wafer and made of a second material, wherein a contact area between the first adhesion layer and the first rigid carrier wafer and/or the product wafer is less than a contact area between the second adhesion layer and the second rigid carrier wafer and/or the product wafer such that both rigid carrier wafers bonded to the product wafer can be separated selectively from the product wafer, after both the first rigid carrier wafer and the second rigid carrier wafer are bonded to the product wafer, applying a first force to the combination of the first rigid carrier wafer, the second rigid carrier wafer and the product wafer wherein the first rigid carrier wafer and the first intermediate layer are separated from the product wafer, and after the first rigid carrier wafer and the first intermediate layer are separated from the product wafer, applying a second force to the second rigid carrier wafer wherein the second rigid carrier wafer and the second intermediate layer are separated from the product wafer.

According to a third aspect of the present invention, there is provided a method for producing a product wafer, the method including steps of: bonding a first side of the product wafer to a first rigid carrier wafer with a first intermediate layer, the first intermediate layer including one first adhesion layer applied at least on the edge side of the first side of the product wafer, the first adhesion layer made of a first material, processing a second side of the product wafer opposite to the first side by application of chips to the second side, bonding the second side of the product wafer to a second rigid carrier wafer with a second intermediate layer, the second intermediate layer including: one second adhesion layer applied at least on the edge side of the second side of the product wafer and made of a second material, wherein a thickness of the first adhesion layer is less than a thickness of the second adhesion layer such that both rigid carrier wafers bonded to the product wafer can be separated selectively from the product wafer, after

both the first rigid carrier wafer and the second rigid carrier wafer are bonded to the product wafer, applying a first force to the combination of the first rigid carrier wafer, the second rigid carrier wafer and the product wafer wherein the first rigid carrier wafer and the first intermediate layer are separated from the product wafer, and after the first rigid carrier wafer and the first intermediate layer are separated from the product wafer, applying a second force to the second rigid carrier wafer wherein the second rigid carrier wafer and the second intermediate layer are separated from the product wafer.

All combinations of at least the two features given in the specification, the claims and/or the figures also fall within the framework of the invention. At the given value ranges, values within the indicated limits will also be disclosed as boundary values and will be claimed in any combination.

~~The basic idea~~ Embodiments of this invention ~~is to~~ provide a method with which the two rigid carrier wafers which are bonded or connected to the respective product wafer can be selectively detached, as a result of which a transfer of the product wafer from the first to the second carrier wafer is enabled, during which the product wafer is being continuously stabilized. This is achieved by the interconnection layers of the two carrier wafers having different properties with respect to their adhesion and/or to the change of their adhesion with action on the interconnection layer, especially by mechanical, thermal, optical and/or chemical methods. It is important here that due to the different properties of the two intermediate layers one of the two intermediate layers is formed or can be changed selectively relative to the other intermediate layer such that this intermediate layer can be detached, while the other intermediate layer maintains its bonding force at least much more strongly than the bonding force of the other intermediate layer. The adhesion is referenced to the effective surface of the interconnection layer.

Fundamentally the selective detachment and/or separation as ~~claimed in~~ per embodiments of the invention

always functions by the different adhesion forces between the carrier wafers and the product wafer, the adhesion force relating to the totality of the intermediate layer between the respective carrier wafer and the product wafer as claimed in the invention. A first group of methods as ~~claimed in~~ per embodiments of the invention is characterized in that the adhesion forces acting between the carrier wafers and the product wafer are inherently, i.e. from the start, different. In this case the intermediate layers therefore have different adhesion forces from the start; on the one hand this is achieved by the intermediate layer consisting of a different material or the contact surfaces of the intermediate layers to the respective carrier wafer and/or to the product wafer being preheated in order to influence the forces acting on the respective contact surfaces. One conceivable embodiment of the invention calls for either adhesion-reducing substances or adhesion-promoting substances to be used to treat the surface of the carrier wafer in whole or in part and/or to treat the surface of the product wafer in whole or in part. There are the following versions which can be applied in combination or individually:

- different adhesive material of the intermediate layers
- different pretreatment of at least one surface/contact surface (in whole or in part) with
    - adhesion-reducing substance
    - adhesion-promoting substance
- different size of the contact surface or thickness of the intermediate layer.

According to a further group of method versions as ~~claimed in~~ per embodiments of the invention, it is provided that an indicated change of the adhesion forces of the intermediate layers is undertaken by certain measures. In this connection, at a selectable defined instant the adhesion force of one of the two intermediate layers or the two intermediate layers is changed such that the adhesion forces of the

two intermediate layers is different after the indicated change of the adhesion force. There are the following possibilities as ~~claimed in~~ per embodiments of the invention:

- controlled local action, especially by irradiation of one intermediate layer, while the other intermediate layer is not irradiated or is only partially irradiated. The controlled local action is possible in another configuration of the invention by the action of solvents on only one intermediate layer while the other intermediate layer is not exposed to solvents or is only partially exposed.
- selectivity by material choice and at least partially inert behavior of one intermediate layer to the applied method step which causes the change of the other intermediate layer, especially by an increase of the temperature, in which one of the two intermediate layers reacts with a less strongly pronounced drop of viscosity, as a result of which this intermediate layer has stronger bonding force against shear forces. It is especially preferred here that one of the two intermediate layers be made inert relative to one solvent, while it dissolves the other intermediate layer.
- change of the adhesion force of the first intermediate layer by action on the first intermediate layer before the second intermediate layer is applied,
- selectivity by ring widths of the edge adhesive zone which are of different magnitude from the start, so that the change of the adhesion force of the first layer is more dramatic than the change of the adhesion force of the second layer by the above described measures.

The rigid carrier wafers are preferably characterized by a high interconnection stiffness. Especially suitable materials, also in combination, are silicone [sic], quartz, glass, ceramic or metal.

Therefore before or during the selective detachment or separation of one of the two carrier

wafers the intermediate layer which is assigned to this carrier wafer or the adhesion layer which is provided in the intermediate layer is changed by chemical, thermal, optical and/or mechanical properties of the adhesion layer or by influence to such a degree that the carrier wafer can be carefully removed without damage, while the product wafer remains on the other carrier wafer. The other carrier wafer stabilizes the product wafer at the same time.

Chips for the purposes of embodiments of this invention are those structures or integrated electronic components which are conventionally applied to a wafer. Bumps or groups of bumps are used for tying the chips to the product wafer or the electronic interconnection of individual circuits of the chip to the corresponding chips or circuits which have applied on the opposite side of the product wafer and/or for later mounting of the entire system on a circuit board.

As a result of the method as ~~claimed in~~per embodiments of the invention not only can a product wafer be provided with chips especially on two sides, but the method as ~~claimed in~~per embodiments of the invention is especially advantageous for stacks of product wafers provided with chips especially on two sides, since selective removal of the carrier wafer yields a careful and effective as well as flexible method for producing stacked product wafers.

Processing of the product wafer can comprise one or more known processes, especially the application of bumps and/or groups of bumps and/or chips to the second side and/or the back-thinning/grinding of the product wafer, as well as the production of so-called redistribution layers (RDL). Product wafers for the purposes of embodiments of this invention also comprise so-called silicon imposers which have only wiring layers (RDL layers) in order to later accommodate chips with active structures.

In another embodiment of the invention, it is provided that the bonding force of the first

adhesion layer is less than the bonding force of the second adhesion layer. Bonding force means the connection force or adhesion force which acts through the respective intermediate layer between the product wafer and the carrier wafer and which counteracts separation of the carrier wafer from the respective product wafer, each referenced to the active bonding area/adhesion area. The difference between the bonding force of the first adhesion layer and the bonding force of the second adhesion layer as ~~claimed in~~ per embodiments of the invention is advantageously so great that when the first carrier wafer is detached from the product wafer the second carrier wafer remains interconnected to the product wafer.

By the first adhesion layer having smaller dimensions than the second adhesion layer, especially a smaller contact area of the first adhesion layer with the first carrier wafer and the product wafer and/or a thinner layer thickness, the invention can be implemented solely by choosing the geometrical configuration so that even in its chemical properties identical intermediate layers or intermediate layers of the same material can be used.

According to another advantageous embodiment of the invention it is provided that the first adhesion layer has chemical properties different from the second adhesion layer such that the first adhesion layer is at least partially dissolved by a first solvent, while the second adhesion layer is at least largely inert with reference to the first solvent. In this way an embodiment of the invention is implemented by the chemical properties of the adhesion layers or intermediate layers.

In other words: The selectivity of the solvents allows controlled dissolution of defined regions, especially edge regions, of the respective adhesion layer or intermediate layer, therefore a selective reduction in the size of the effective adhesion area/bonding area.

Here it is advantageous if the ratio of the dissolution rate A_1 of the first solvent relative to

preferably 20 to 40 μm, even more preferably 25 to 30 μm.

In another advantageous embodiment of the invention, it is provided that the first and/or the second adhesion layer are made annular, especially in the region of the periphery of the product wafer. In this way the adhesion layer can be processed in terms of the periphery; this is especially advantageous when using solvents since the solvent in this case need diffuse only over a very short distance.

According to another embodiment of the invention it is advantageously provided that the first intermediate layer, especially within the annular adhesion layer, comprises a film with low adhesion action and/or the second intermediate layer comprises a film with low adhesion action which is located especially within the annular adhesion layer. Low adhesion action in relation to the adhesion action of the adhesion layer is meant and is especially at least twice, preferably at least triple, even more preferably at least five times, ideally at least ten times, stronger. The relation is referenced to the adhesion action in a dynamic stale, therefore during the separation process, but especially in addition is referenced to the static state, therefore prior to the separation process. The film according to one embodiment of this invention can be provided as a partial coating of the first and/or second intermediate layer or the first and/or second adhesion layer, the partial coating leading to a reduction of the adhesion action, especially as an antiadhesion coating. It is important here that the film reduces a part of the effective contact surface of the respective intermediate layer with the corresponding carrier wafer in the adhesion action.

A device provided as ~~claimed in~~per embodiments of the invention has suitable means for application of the above described method, specifically selective separating agents for selective separation of the first carrier wafer from the product wafer as a result of the different properties of the first intermediate

layer from the second intermediate layer. Known devices can be used for mechanical separation, for example by applying opposite tensile forces to the first carrier wafer and to the second carrier wafer away from the product wafer or a shearing force to the first carrier wafer and to the second carrier wafer in the opposite direction along the product wafer. The selective separating agents are however as ~~claimed in~~ per embodiments of the invention made such that there are suitable devices for selective separation.

Other advantages, features and details of the invention will become apparent from the following description of preferred exemplary embodiments and using the drawings which are sectional views:

Figure 1 shows a product wafer in a first method step as claimed in the invention,

Figure 2 shows a product wafer in a second method step as claimed in the invention,

Figure 3 shows a product wafer in a third method step as claimed in the invention,

Figure 4 shows a product wafer in a fourth method step as claimed in the invention,

Figure 5 shows a product wafer in a fifth method step as claimed in the invention,

Figure 6 shows a product wafer in a sixth method step as claimed in the invention,

Figure 7 shows a product wafer in a seventh method step as claimed in the invention,

Figure 8 shows a product wafer in an eighth method step as claimed in the invention,

Figure 9 shows a product wafer in a ninth method step as claimed in the invention,

Figure 10 shows a product wafer in a tenth method step as claimed in the invention,

Figure 11 shows a product wafer in an alternative seventh method step as claimed in the invention,

Figure 12 shows a product wafer in an alternative seventh method step as claimed in the invention.