Pressure Transmission Apparatus for Bonding of Chips to a Substrate

Specification

This invention relates to a pressure transmission apparatus for bonding a plurality of chips to a substrate ~~as claimed in Claim 1~~ and a bonding device for bonding a plurality of chips to a substrate ~~as claimed in Claim 8~~.

In the semiconductor industry there are several possibilities for connecting, especially bonding, different functional units to one another. One of these possibilities is the chip-to-wafer (C2W) method in which individual chips are bonded individually to a substrate. Another important method is the so-called "advanced chip-to-wafer" (AC2W) method in which the chips are first tentatively (temporarily) joined to the substrate and a permanent connection takes place in one bonding step, all chips being permanently bonded to the substrate at the same time. In the bonding step the chips and the substrate are heated while the chips are being pressed onto the substrate (bonding force).

The aforementioned pressure and heating processes engender technical problems especially for structures which are becoming smaller and smaller, for example due to thermal expansion during heating.

~~Therefore the object~~Embodiments of this invention ~~is to devise~~ disclose a pressure transmission apparatus and a bonding device with which the aforementioned method can be optimized and scrap is minimized during bonding.

~~This object is achieved with the features of Claims 1 and 8. Advantageous developments of the invention are given in the dependent claims.~~ According to a first aspect, there is provided a pressure transmission apparatus for bonding a plurality of chips to a substrate with:

- a pressure body for applying a bonding force which acts in the bonding direction to the chip, the pressure body having a first pressure side and an opposite second pressure side which run transversely to the bonding direction,
- fixing means which can be attached to the periphery of the pressure transmission apparatus for fixing of the pressure transmission apparatus on a retaining body in the bonding direction, and
- a sliding layer for sliding motion of the pressure body transversely to the bonding direction, characterized in that the fixing means

a) being made elastic transversely to the bonding direction and/or

b) are made as clamps for clamping of the pressure body in the direction of the retaining body, especially with a sliding layer located in between

According to a second aspect, there is provided a bonding device for bonding a plurality of chips to a substrate with:

- a pressure transmission apparatus as claimed in one of the preceding claims,
- the retaining body,
- a receiver for accommodating the substrate,
- heating means for heating of the chip and of the substrate,

- drive means for producing the bonding force, especially by movement of the retaining body in the bonding direction.

According to a third aspect, there is provided a method for bonding a plurality of chips on a substrate with the above transmission apparatus or the above transmission method.

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

~~The basic idea~~Embodiments of this invention ~~is to configure~~provide a pressure transmission apparatus for bonding of a plurality of chips to a substrate such that it is made to allow a sliding motion of the pressure body transversely to the bonding direction B. But it is advantageous if there are limiting means for limiting the sliding motion transversely to the bonding direction B, especially in the form of fixing means for fixing of the pressure transmission apparatus on a retaining body in the bonding direction B. The use of this invention is especially advantageous with an AC2W method in which the chips are temporarily joined to the substrate and then bonded using the pressure transmission apparatus in a bonding process. As ~~claimed~~per embodiments of ~~in~~ the invention it is advantageous here if prior to the pressure transmission the process of heating to the bonding temperature is at least largely completed. In this way the pressure body can slide transversely to the bonding direction B more freely than with an adjacent bonding force in the bonding direction B.

The substrate is especially a semiconductor, preferably a wafer.

~~The~~Embodiments of the invention largely solve~~s~~ the technical problem of thermal stresses which occur during bonding between the pressure transmission apparatus and the chip surfaces since only the stresses of the pressure body itself are relevant since it is at least largely decoupled from all components on the other side of the sliding layer transversely to the bonding direction B by the sliding layer as ~~claimed~~

~~in~~per embodiments of the invention. The sliding layer thus allows almost completely frictionless relative motion of the components bordering it. As ~~claimed~~ per embodiments of ~~in~~ the invention the sliding layer is made especially as a preferably largely carbon-containing solid. Graphite whose basal planes is aligned at least largely perpendicular to the bonding direction B is chosen as the material.

According to one advantageous embodiment of the invention it is provided that the fixing means are made elastic transversely to the bonding direction B. Thus at the same time the fixing means can provide for holding the pressure transmission apparatus together in the bonding direction B while the sliding motion of the pressure body transversely to the bonding direction B is allowed. At the same time the fixing means can act in this way as the above described limiting means and thus can assume several functions as ~~claimed in~~per embodiments of the invention.

Here it is especially advantageous if the fixing means are made as clamps for clamping a pressure body in the direction of the retaining body, especially with the sliding layer located in between. This configuration can be implemented especially easily in a space-saving manner and performs the aforementioned multiple functions.

In one ~~development~~embodiment of the invention it is provided that the pressure body, especially with respect to material and/or dimensions, is chosen such that its thermal expansion properties at least in the transverse direction to the bonding direction B correspond to the thermal expansion properties of the product substrate. The material is preferably the material of the substrate and/or of the chip. It is especially advantageous as ~~claimed in~~per embodiments of the invention if the dimensions of the pressure body

essentially agree with the dimensions of the substrate, especially transversely to the bonding direction B. The thermal expansion properties comprise especially the coefficient of thermal

expansion of the pressure body and/or of the substrate and/or of the chip. In particular, but not exclusively, material classes such as metal, ceramics, plastics or composite materials can be used, in particular Si, CTE matched glass, therefore glass whose coefficient of thermal expansion has been aligned to that of the product substrate, low CTE metals, etc. CTE matched glass and low CTE metals are also known. Mainly materials whose thermal conductivity is very high are preferred. The coefficient of thermal expansion of silicon is for example $2.6 \cdot 10^{-6}$ K^{-1}. The absolute amount of the difference of the coefficients of thermal expansion of the product substrate and the embodiment ~~as claimed in~~of the invention is less than $100 \cdot 10^{-6}$ K^{-1}, preferably less than $10 \cdot 10^{-6}$ K^{-1}, more preferably less than $1 \cdot 10^{-6}$ K^{-1}, most preferably less than $0.1 \cdot 10^{-6}$ K^{-1} , most preferably of all less than $0.01 \cdot 10^{-6}$ K^{-1}, most ideally 0 K^{-1}.

By there being a layer which is elastic at least in the bonding direction B and especially which is at least partially interrupted on intermediate spaces of the chip for pressure compensation, the pressure transmission apparatus also compensates for expansions, stresses and height differences in the bonding direction B so that uniform pressure application is enabled. The elastic layer is thus used as a compensation layer. In particular the elastic layer has a modulus of elasticity between 1 MPa and 100 GPa, preferably between 1 MPa and 10 GPa, even more preferably between 1 MPa and 1 GPa. Preferred materials are polymers. Rubber with an effective isotropic modulus of elasticity of roughly 1 MPa is used as the comparison value of the modulus of elasticity. Fiber-reinforced polymers are preferred with an effective modulus of elasticity along the longitudinal axis of the fiber of roughly 100 GPa. They mark the upper limit of the elastic material.

In another advantageous embodiment of the invention it is provided that between the

pressure body and the chip there is a hard layer which is at least partially interrupted especially on intermediate spaces of the chip for direct pressure transmission to the chips. The hard layer has a greater modulus of elasticity (especially twice as great) than the elastic layer, the hard layer being used as a protective layer. In particular the hard layer is also used to form a planar surface, especially with an average surface roughness of less than 10 μm, preferably less than 1 μm, even more preferably less than 100 nm, most preferably less than 10 nm. The hard layer is preferably made as an ultrahard layer. Preferred materials are metals and ceramics, especially iron materials, nonferrous metals, hard metals, nitride layers, carbide layers, boride layers and oxide ceramics. The thickness of the hard layer in the bonding direction B is less than 10 mm, more preferably less than 5 mm, even more preferably less than 2 mm, most preferably less than 500 μm, most preferably of all less than 100 μm.

Advantageously according to another embodiment it is provided that the pressure body has fixing sites which are located on the periphery of the first pressure side, especially in the form of a preferably ring-shaped offset. In this way space-saving fixing of the pressure body on the retaining body is possible, due to possible heat transfer from the retaining body to the chips which are to be bonded during bonding a configuration of the pressure transmission apparatus as thin as possible in the bonding direction B being advantageous.

The described features of the pressure transmission apparatus apply analogously to the bonding device as ~~claimed~~per embodiments of ~~in~~ the invention.

Other advantages, features and details of the invention will become apparent from the following description of preferred exemplary embodiments and using the drawings.

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Claims

1. A pressure transmission apparatus for bonding a plurality of chips (13) to a substrate (12) with:

- a pressure body (2) for applying a bonding force which acts in the bonding direction (B) to the chip (13), the pressure body (2) having a first pressure side (2o) and an opposite second pressure side (2f) which run transversely to the bonding direction (B),
- fixing means (8, 8', 8") which can be attached to the periphery of the pressure transmission apparatus (1) for fixing of the pressure transmission apparatus (1) on a retaining body (9) in the bonding direction (B), and
- a sliding layer (3) for sliding motion of the pressure body (2) transversely to the bonding direction (B),

characterized in that the fixing means (8, 8', 8")

a) being made elastic transversely to the bonding direction (b) and/or

b) are made as clamps for clamping of the pressure body (2) in the direction of the retaining

body (9), especially with a sliding layer (3) located in between

2. The pressure transmission apparatus as claimed in Claim 1, wherein there is a layer (6) which is elastic at least in the bonding direction (B) and especially which is at least interrupted on intermediate spaces (15) of the chip (13) for pressure compensation.

3. The pressure transmission apparatus as claimed in one of the preceding claims, in which between the pressure body (2) and the chip (13) there is a hard layer (7) which is interrupted especially on intermediate spaces (15) of the chip (13) for direct pressure transmission to the chips (13).

4. The pressure transmission apparatus as claimed in one of the preceding claims, in which the pressure body (2) has fixing sites which are located on the periphery of the first pressure side (2o), especially in the form of a preferably ring-shaped offset.

5. A bonding device for bonding a plurality of chips (13) to a substrate (12) with:

- a pressure transmission apparatus (1) as claimed in one of the preceding claims,
- the retaining body (9),
- a receiver (10) for accommodating the substrate (12),
- heating means for heating of the chip (13) and of the substrate (12),
- drive means for producing the bonding force, especially by movement of the retaining body (9) in the bonding direction (B).

6. Method for bonding a plurality of chips (13) on a substrate (12) with a pressure transmission apparatus (1) according to claim 1 or a bonding device according to claim 5.

7. Method according to claim 6, wherein the pressure body (2), especially with respect to material and/or dimensions, is chosen such that its thermal expansion properties at least in the transverse direction to the bonding direction (B) correspond to the thermal expansion properties of the substrate (2).