Method and Device for Determining

the Pressure Distribution for Bonding

The invention relates to a method and a device for determining the pressure distribution in a boundary layer of two tools via the deformation of viscous or plastically deformable media~~according to Claim 1 and 9~~.

During a bonding process, the pressure distribution on the wafers which are to be welded is of immense importance. The pressure distribution is a direct property of the surface waviness and surface roughness of the contacting surfaces of all tools which lie over or under the wafer. The tools include mainly heaters, clamping plates, compensation plates, receivers (bond chucks), etc. The knowledge of the surface waviness and surface roughness of the tool whose surface is in direct contact with one of the wafers is not sufficient for computing the pressure distribution. Therefore with ordinary measurement methods such as AFM, laser interferometry, white light interferometry it is not possible to obtain direct and reliable information about the pressure distribution of the bonding process. These measurement methods are used solely and alone for determining the topography of the surface of the tool which is directly in contact with one of the wafers which are to be welded. The homogeneity of the pressure distribution has a very great influence on the bond quality, from which the scrap rate of completely bonded wafers and the scrap rate of the functional components which are located on the wafer follow. Different adverse consequences in the case of insufficient uniformity of the pressure and/or of uneven tools will be briefly mentioned here. In the case of bonding interfaces which cannot be deformed or which can hardly be deformed, for

plate is possible due to the size of the force transducers.

Embodiments of the present invention~~The object of these inventions is therefore to~~ provide a method which can be integrated into method sequences and which can especially be automated, as well as a corresponding device with which the pressure distribution between the tools can be measured at regular intervals as easily and accurately as possible. Here the measurement means should be re-usable as much as possible. The method as per embodiments of~~claimed in~~ the invention should be usable as much as possible under real process conditions.

~~This object is achieved with the features of Claims 1 and 9. Advantageous developments of the invention are given in the dependent claims.~~According to a first aspect, there is provided a method for determining the pressure distribution for wafer bonding of a first substrate to a second substrate, with the following steps, especially with the following sequence; placing a measurement layer between a first tool for holding the first substrate and an opposite second tool which is aligned to the first tool for bonding of the substrates, deformation of the measurement layer by bringing the tools closer to one another, optical measurement of the deformation of the measurement layer and computation of the pressure distribution based on the measurement of the deformation.

According to a second aspect, there is provided a device for determining the pressure distribution for wafer bonding of a first substrate to a second substrate, with: introducing means for introducing or applying a measurement layer between a first tool and an opposite second tool which is aligned to the first tool, deformation means for deformation of the measurement layer by moving the tools toward one another, optical measurement means for measuring of the deformation of the measurement layer and computation means for computing the pressure distribution based on the measuring of the deformation.

According to a third aspect, there is provided a method determining the pressure distribution for wafer bonding of a first substrate to a second substrate, with the following steps, especially with the following sequence: placing a measurement layer between a first tool for holding the first substrate and an opposite second tool which is aligned to the first tool for bonding of the substrates, deformation of the measurement layer parallel to the surface of the substrate by bringing the tools closer to one another, measurement of the deformation of the measurement layer and computation of the pressure distribution based on the measurement of the deformation.

All combinations of at least two of the 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 which lie within the indicated boundaries will also be considered disclosed as boundary values and will be claimed in any combination. Apparatus features will also be considered disclosed as method features and vice versa.

Embodiments of the~~This~~ invention are~~is~~ based on the fundamental idea of being able to draw conclusions about the pressure distribution as exactly as possible by measurement of the especially local deformation or order of magnitudes of a measurement layer which is placed between the receiver (tool) and the clamping plate (tool). The thickness of the measurement layer during measurement is less than 200 µm, preferably less than 100 µm, more preferably less than 50 µm, even more preferably less than 10 µm, most preferably less than 5 µm, most preferably of all less than 1 µm. The preferred thickness of the measurement layer depends mainly on the bond process which is to be used. If the method as claimed in the invention is to be used to ascertain the pressure distribution for a later metal-metal bond, as per embodiments of~~claimed in~~ the invention very thin layers are chosen, preferably smaller than

10 μm, more preferably smaller than 5 μm, most preferably smaller than 1 μm.

For bond processes with moderately deformable bond interfaces, for example eutectic bonds, which run through a liquid phase, as claimed in the invention layer thicknesses smaller than 50 μm, preferably smaller than 10 μm, most preferably smaller than 5 μm are used.

For bond processes with very easily deformable bond interfaces, for example temporary bonding adhesives, very thick layers are used as per embodiments of~~claimed in~~ the invention. The layer thicknesses are preferably smaller than 200 μm, more preferably smaller than 100 μm, most preferably smaller than 50 μm.

Overlaps of the indicated layer thickness ranges are allowed and possible, depending on the exact bond process and material.

Thus, the sole consumable material for the measurement method as per embodiments of~~claimed in~~ the invention and the measurement device as per embodiments of~~claimed in~~ the invention is the measurement layer which is deformed by application of pressure or by movement of the clamping plate and receiver onto one another. The relative deformation of the measurement layer which is caused especially parallel to the surface of the wafer is then measured and evaluated, and based on the especially local deformation of the measurement layer conclusions about the pressure distribution in the boundary layer between the tools can be drawn. The method as per embodiments of~~claimed in~~ the invention can also be used at higher temperatures, preferably above room temperature, more preferably above 200°C, even more preferably above 400°C, most preferably above 600°C. The measurement can be taken especially optically, preferably by cameras. Optics are used to enlarge the layers which are to be measured. A two-dimensional measurement of the deformation in an aspect of the surface of the measurement layer, especially orthogonally to the surface of the wafer, is advantageous. In particular the change

of the diameter or the spreading of the measurement layer can be detected.

According to one advantageous embodiment of the invention it is provided that wafers which are aligned to one another are placed between the measurement layer and the tools which lie over or under it. In this way the deformation of the measurement layer takes place under realistic conditions and the removal of the measurement layer can take place especially without residue after the measurement is taken. Realistic conditions mean states under the actual bond process take place. These states are characterized by increased temperature, vacuum, increase pressure and similar parameters. Moreover the idle times of the device, to the extent measurement takes place in-line, is minimized by the preparation and also the measurement being able to proceed independently of the tools or the bonding apparatus.

To the extent the shape of the measurement layer is measured before deformation, the accuracy of the measurement of deformation is greatly increased. A measurement of the shape of the measurement layer after deformation is absolutely necessary to be able to compute the corresponding force and thus the pressure at the corresponding point.

According to another advantageous embodiment of the invention, it is provided that the measurement layer consists of fluid, especially curable, material. Accordingly the application or introduction of the measurement layer by a droplet dispenser which enables a controlled and reproducible application, especially in the form of droplets or paths, is enabled. In application in defined size or a defined volume the prior measurement of the measurement layer before deformation of the measurement layer can also be omitted, as a result of which a further acceleration of the method as per embodiments of~~claimed in~~ the invention becomes possible.

This is further optimized by distribution means, especially in the form of a droplet