Measuring Device and Method for Determining a Pressure Map

Specification

This invention relates to a measuring device. Furthermore this invention relates to a method for determining a pressure map.

In the semiconductor industry, in general substrates of different sizes, shapes and materials are joined to one another. The joining method is called wafer bonding. Wafer bonding is roughly divided into permanent and temporary bonding. In permanent bonding a no longer detachable connection between the substrates is formed. This permanent connection takes place for example by interdiffusion of metals, by cation-anion transport in anodic bonding or by the formation of covalent bonds between oxides and/or semiconductor materials in fusion bonding, and in the crosslinking of polymers in bonds with organic cements.

In temporary bonding mainly so-called bonding adhesives are used. They are adhesives which are applied to the surface of one or both substrates by a coating method in order to act as adhesive between the substrates.

In all bonding methods bonders are used to apply a blanket pressure as uniform as possible to the substrates to be bonded to one another. Here it is of very great importance that the pressure distribution along the surface of the substrates is optimum. Otherwise voids can arise due to gas inclusions, by squeeze-out, by absent grain growth and by nonuniform layer thicknesses.

Pressure inhomogeneities can be attributed mainly to poorly manufactured pressure disks, wafer chucks or to their wear. Furthermore the different elastic properties of the components which generate the compressive load on the substrates are responsible for many pressure inhomogeneities. This is mainly the case when the moduli of elasticity of the components of the bonder are smaller than the moduli of elasticity of the substrates to be bonded or the layers which are located between the substrates. In order to obtain a corresponding elasticity of the bonder, pressure disks, wafer chucks or compensation disks produced from special materials such as graphite are used to obtain the optimum bonder configuration. In very many cases for example graphite compensation disks of corresponding size are fixed between the pressure disk and the piston. The use of these compensation disks depends on the respective configuration and the bond type. Graphite compensation disks have been used most often to date since they deform very well, are temperature-stable and have a corresponding modulus of elasticity under full compressive loading. Generally the

use of these compensation disks improves the pressure homogeneity.

Therefore methods are known for obtaining quantitative information about the pressure distributions along the pressure surfaces.

The most frequently used method is the evaluation of the color information on paper which is colored to different degrees by bursting of color balls at high pressure. Although this method is current practice, it has disadvantages. Cutting out the films, installing them between the pressure bodies and removing them are accordingly time-consuming. Moreover the material cannot be used under thermal loading due to high temperature sensitivity; this also causes problems in the reproducibility of the results. Another problem is the numerical evaluation of the pressure data, which evaluation is not reliable or reproducible.

A second already known method was disclosed in WO2012/ 167814A1. This method is based on the evaluation of the deformation of fluid particles caused by the compressive load. This method does not allow in-situ measurement of the pressure distribution between the pressure bodies either.

A third, already known method uses a measuring device of hundreds of locally distributed pressure sensors which must be produced on a corresponding substrate, which method is complex and especially costly. Production takes place using microsystems technology. The microsensors are MEMS and/or semiconductor elements which can control a current, depending on the respective compressive loading.

Embodiments of this invention devise a measuring device and a method for determining a pressure map with which the aforementioned disadvantages are at least largely eliminated.

According to a first aspect of the present invention, there is provided a bond-pressure-measuring device, ~~comprising at least one measurement layer of an optical material, wherein an optical property of the optical material is changeable dependent on pressure applied to the at least one measurement layer,~~ for determining a pressure map during ~~the~~ application of pressure to ~~the~~ at least one measurement layer between a first pressure body and a second pressure body ~~before and/or during a bond process with the following~~ and for determining the pressure distribution in the measurement layer, which is applied with pressure by the pressure bodies with: at least one transmitter located on one peripheral edge of the measurement layer for emission of signals in the form of electromagnetic waves along a first signal route which runs through the measurement layer

and at least one other signal route which runs through the measurement layer, at least one receiver located on the peripheral edge for the reception of the signals of the first signal route and other signal route(s), which signals are sent by the transmitter through the measurement layer and can be changed when pressure is applied.

According to a second aspect of the present invention, there is provided a bond-pressure-measuring method for determining a pressure map for pressure application to a measurement layer ~~of an optical material~~ between a first pressure body and a second pressure body ~~before and/or during a bond process with the following steps, especially the following sequence, wherein an optical property of the optical material is changed dependent on the pressure applied to the measurement layer,~~ and for determining the pressure distribution in the measurement layer, which is applied with pressure by the pressure bodies with the following steps, especially the following sequence: arrangement of ~~a~~ the above measuring device ~~according to one of the preceding claims~~ between the first pressure body and the second pressure body, emission of signals in the form of electromagnetic waves by the transmitter(s) located on the peripheral edge along a first signal route which runs through the measurement layer and at least one other signal route which runs through the measurement layer, reception of the signals by the receiver(s) located on the peripheral edge for receiving the signals of the first signal route and other signal route(s), which signals are sent by the transmitter(s) through the measurement layer and which can be changed when pressure is applied.

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 of embodiments of this invention is to measure at least one physical parameter of at least one electromagnetic wave or several electromagnetic waves after passing through a measurement layer, especially in-situ, and to compute from the measured data a pressure, preferably a pressure distribution, in the measurement layer. Preferably all physical parameters of all waves, which parameters are to be measured, are measured before entering the measurement layer and afterwards. As per embodiments of the invention, the measurement comprises a plurality of signal routes of the electromagnetic waves, therefore measured distances, and from the different, especially crossing

~~Amended~~ Claims

1. A bond-pressure-measuring device, ~~comprising at least one measurement layer (3) of an optical material, wherein an optical property of the optical material is changeable dependent on pressure applied to the at least one measurement layer (3),~~ for determining a pressure map during ~~the~~ application of pressure to ~~the~~ at least one measurement layer (3) between a first pressure body (5) and a second pressure body (6) ~~before and/or during a bond process with the following~~ and for determining the pressure distribution in the measurement layer (3), which is applied with pressure by the pressure bodies (5, 6) with:

- at least one transmitter (7) located on one peripheral edge (3u) of the measurement layer (3) for emission of signals (9) in the form of electromagnetic waves along a first signal route which runs through the measurement layer (3) and at least one other signal route which runs through the measurement layer (3),
- at least one receiver (8, 8') located on the peripheral edge (3u) for the reception of the signals (9) of the first signal route and other signal route(s), which signals are sent by the transmitter (7) through the measurement layer (3) and can be changed when pressure is applied.

2. The measuring device as claimed in Claim 1, which can be used in a wafer processing device, especially in-situ.

3. The measuring device as claimed in at least one of the preceding claims, wherein the transmitter (7) and/or the receiver (8, 8') can be moved along the peripheral edge (3u).

4. The measuring device as claimed in at least one of the preceding claims, which has several transmitters (7) distributed on the peripheral edge (3u) and/or several receivers (8, 8') which are distributed on the peripheral edge (3u) and which are assigned to one, especially opposite transmitter (7) at a time, especially at least two receivers (8, 8') per transmitter (7).

5. The measuring device as claimed in at least one of the preceding claims, wherein each transmitter (7) emits several signal routes, especially at the same time, and/or each receiver (8, 8') is assigned to one single signal route at a time.

6. The measuring device as claimed in at least one of the preceding claims with one evaluation unit for determining localized pressure values of the pressure map along the signal routes, especially by a transform, preferably Radon transform, of the signals (9) received by at least one receiver (8, 8').

7. The measuring device as claimed in at least one of the preceding claims, wherein the at least one receiver (8, 8') is made to acquire optical properties of the signal (9), especially one or more of the following optical properties:

- double refraction
- index of refraction
- mode of signals shaped as transverse electromagnetic waves
- transit time
- spectral coding.

8. A bond-pressure-measuring method for determining a pressure map for pressure application to a measurement layer (3) ~~of an optical material~~ between a first pressure body (5) and a second pressure body (6) ~~before and/or during a bond process with the following steps, especially the following sequence, wherein an optical property of the optical material is changed dependent on the pressure applied to the measurement layer (3),~~ and for determining the pressure distribution in the measurement layer (3), which is applied with pressure by the pressure bodies (5, 6) with the following steps, especially the following sequence:

- arrangement of a measuring device according to one of the preceding claims between the first pressure body (5) and the second pressure body (6),
- emission of signals (9) in the form of electromagnetic waves by the transmitter(s) (7) located on the peripheral edge (3u) along a first signal route which runs through the measurement layer (3) and at least one other signal route which runs through the measurement layer (3),
- reception of the signals (9) by the receiver(s) (8, 8') located on the peripheral edge (3u) for receiving the signals (9) of the first signal route and other signal route(s), which signals are sent by the transmitter(s) (9) through the measurement layer (3) and which can be changed when pressure is applied.