Pressure Transfer Disk for Transfer of a Bonding Pressure

Specification

The invention relates to a pressure transfer disk for transfer of a bonding pressure, especially in thermocompression bonding, from a pressurization apparatus to a wafer ~~according to Claim 1~~ and as well as an application ~~according to Claim 10~~ of the pressure transfer disk during bonding.

One of the innumerable bond methods is thermocompression bonding. In this bonding method two wafers are permanently joined/bonded to one another at very high pressures and temperatures. In order to obtain a bonding interface which is as uniform as possible, the tools, the bond chucks (bond sample holders) and the pressure disks are produced with surface roughnesses which are as low as possible. Preferably these tools have no surface roughness at all, are perfectly planar, and have no defects, as much as possible. To level possible macroscopic unevenness and/or ripples, leveling disks, for example graphite disks, can be attached on one or both sides of the pressure disks. These leveling disks are soft and deformable. The leveling disks in the bond process are accordingly located between the pressure disk and the tool which lies behind it and/or the top of a wafer which is to be bonded.

For most bonding methods the leveling disks perform their task of leveling unevenness. They do this mainly by efficient filling of the space between the leveling disk and the wafer. But in thermocompression bonding the problem arises that the compensation of unevenness by this filling as a result of high pressure and temperatures is in the meantime so efficient that the wafers remain suspended on the pressure disk or leveling disk. If the bond chamber is opened after the bond

process, it thus occurs that the wafer is damaged by it. The damage takes place mainly due to the wafer's adhering to the surface of the pressure disk or the leveling disk when the bond chamber is opened and losing adhesion spontaneously after a few milliseconds to seconds. For this reason the wafer falls back, undergoes impact and is damaged. Embodiments~~It is therefore the object~~ of this invention disclose~~to devise~~ a pressure transfer disk with which damage can be avoided during bonding, especially when the bonded wafer is removed from the bonding device.

According to a first aspect, there is provided a pressure transfer disk for transfer of a bonding pressure from a pressurization apparatus to a wafer with the following: a first pressure side for making contact with the pressurization apparatus, a second pressure side facing away from the first pressure side with an effective contact area for making contact with the wafer and pressurizing it, at least the effective contact area having a low adhesiveness relative to the wafer, wherein the pressure transfer disk is made as a lattice network, wherein the pressure transfer disk is for transfer of the bonding pressure in thermocompression bonding, and wherein the lattice network has a mesh width M less than 1 mm.

According to a second aspect, there is provided an application of the above pressure transfer disk during bonding, in particular in thermocompression bonding.

~~This object is achieved with the features of Claims 1 and 10. Advantageous developments of the invention are given in the dependent claims.~~ 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.

Embodiments of tThe invention areis based on the idea of facilitating the release of the wafer from the pressurization apparatus and of thus avoiding damage by attaching to the pressurizing apparatus a pressure transfer disk which is of low adhesion relative to wafers, therefore between the pressure transfer disk and the wafer. By reducing the adhesion the wafer after bonding can be released from the respective pressure disk without adhesion causing damage to the wafer, for example by falling down. As elaimed inper embodiments of the invention a reliable release from the pressure transfer disk while maintaining the remaining advantageous properties is ensured.

Adhesiveness as elaimed inper embodiments of the invention designates a certain retaining force per m^2 which as elaimed inper embodiments of the invention should be as low as possible so that the overwhelming part of the fixing of the substrate on the receiving surface is caused by fixing means in the fixing section.

If the adhesion between two solids which are joined to one another is to be determined, the

energy which is required to drive a crack through the solid can be measured. In the semiconductor industry the so-called "razor blade test" or "Maszara razor blade test" is often used. This test, strictly speaking, is a method for determining the bonding energy between two solids. Generally the solids are welded to one another. As ~~claimed in~~per embodiments of the invention other measurement methods are preferably used in order to determine the adhesiveness of a layer at this point, which should be of low adhesion relative to as many different materials as possible. The most frequently used measurement method is the contact angle method.

The contact angle method is used together with the Young equation in order to obtain evidence about the surface energy of a solid by using a test liquid.

It qualifies the surface energy of a surface by a certain test liquid, generally by water. Corresponding measurement methods and the evaluation methods are known to one skilled in the art. The contact angle which is determined with the contact angle method can be converted to a surface energy in N/m or J/m^2. For relative comparison of different surfaces for the same test liquid the information about the contact angle is sufficient to obtain a (relative) estimate of the adhesiveness of the surface. Thus, by using water as the test liquid it can be stated that wetted surfaces which produce a contact angle on the water droplet of roughly 30° have higher adhesion (strictly speaking only to water) than surfaces whose contact angle on the water droplet has roughly 120°.

The embodiment ~~as claimed in the invention~~ will be preferably used to pressurize Si wafers. Therefore a determination of the surface energy of any low adhesion layer used as ~~claimed in~~per embodiments of the invention to Si would be desirable. Since Si is not liquid at room temperature, as mentioned above, a test liquid is used to characterize the low adhesion layer as ~~claimed in~~per embodiments of the invention with respect

to this test liquid. All following contact angle values and/or surface energies are thus values which quantify the low adhesion layer as ~~claimed in~~per embodiments of the invention with respect to a test liquid and allow at least relative evidence about the adhesiveness to other substances, preferably solids, even more preferably Si.

In one preferred embodiment of the invention it is provided that the adhesiveness is defined by a surface energy of less than 0.1 J/m^2, especially less than 0.01 J/m^2, preferably less than 0.001 J/m^2, even more preferably less than 0.0001 J/m^2, ideally less than 0.00001 J/m^2.

Alternatively or additionally, according to one advantageous embodiment of the invention it is provided that the adhesiveness of the contact area is defined with a contact angle greater than 20°, especially greater than 50°, preferably greater than 90°, even more preferably greater than 150°. The adhesiveness of a surface to another material can be determined using the aforementioned contact angle method. Here a droplet of a known liquid, preferably water (values as ~~claimed in~~per embodiments of the invention relative to water) (alternatively glycerin or hexadecane), is deposited on the surface to be measured. Using a microscope the angle is measured exactly from the side, specifically the angle between the tangent on the droplet and the surface.

According to another advantageous embodiment of the invention it is provided that the pressure transfer disk is made as a lattice network, especially with a mesh width M less than 2 mm, preferably less than 1 mm, more preferably less than 0.5 mm, even more preferably less than 0.1 mm, most preferably less than 0.01 mm. For one skilled in the art in the field, it is clear that the optimum mesh width can also depend on the diameter and the thickness of the wafer and is empirically determined in particular by tests. The antiadhesion action is caused by the very small, but finite mesh width M. The mesh width M is as ~~claimed in~~per embodiments of the invention small enough to transfer

the homogenous pressure distribution of the pressure transfer apparatus in the best possible manner to a surface of the wafer, at the same time it reduces the absolute contact area such that an adhesion of the wafer on the pressure transfer apparatus, especially on an upper tool, is no longer possible or is at least smaller than the force due to the weight of the wafer.

Alternatively or in addition, in one ~~development~~embodiment of the invention it is provided that at least the contact area of the second pressure side has a surface roughness produced especially by shotpeening, sandblasting, grinding, etching and/or polishing between 100 nm and 100 μm, especially between 1 μm and 10 μm, even more preferably between 3μm and 5 μm. The surface roughness can be referenced especially to the wafer thickness and/or the wafer diameter. It can happen that for a certain wafer diameter and/or a certain wafer thickness there is an optimum roughness. The latter is accordingly determined empirically as ~~claimed in~~per embodiments of the invention. In one preferred embodiment the surface roughness is produced wet-chemically. By using acids the surface is eroded in a controlled manner. A surface with corresponding roughness is produced by the indicated methods shotpeening, sandblasting, grinding and/or polishing with correspondingly large grain sizes. The resulting effect of the antiadhesion action is similar to the effect of the lattice network, only that in this case not a regular mesh structure, but an irregular surface causes the desired effect of low adhesion.

It is known from nanotechnology that low adhesion surfaces in the microrange and/or the nanorange whose morphology contributes to the low adhesion or even causes it have extreme unevenness. One example which is known to one skilled in the art is the so-called "lotus blossom effect".

To the extent the pressure transfer disk is formed from a material which is

thermodynamically stable up to at least 400°C, especially up to at least 800°C, preferably up to at least 1200°C, even more preferably up to at least 2000°C, still more preferably up to at least 3000°C, the pressure transfer disk can advantageously be used in thermocompression bonding.

It is especially advantageous here if the pressure transfer disk is formed from a material which especially has a uniform and high compressive strength over a large temperature range, especially at temperatures above 400°C, which strength is greater than 100 MPa, especially greater than 500 MPa, preferably greater than 1000 MPa, even more preferably greater than 2000 MPa. The compressive strength can be increased especially by boundary means on the lateral periphery of the pressure disk (at least biaxial compressive strength).

Conceivable material classes would be especially the following:

high temperature plastics,

ceramics, SiC, SiN, etc.

metals,

refractory metals,

thermal stability steels,

general tool steels

or any combination of the aforementioned materials.

As ~~claimed in~~per embodiments of the invention the pressure transfer disk advantageously has a certain elasticity/deformability so that unevenness or ripple of the wafer and/or of the pressure transfer apparatus are leveled when pressure is applied.

According to another advantageous embodiment, it is provided that the pressure transfer disk has a thickness d less than 15 mm, preferably less than 10 mm, more preferably less than 5

mm, even more preferably less than 1 mm, most preferably less than 0.1 mm, most preferably of all less than 0.05 mm.

Furthermore it is advantageous if in one ~~development~~embodiment of the invention at least the second pressure side, preferably the entire pressure transfer disk, is formed from a material which is inert relative to the wafer under given conditions and or does not react with the wafer material and/or is not soluble relative to the wafer material. Especially for wafers which have logic families which are highly sensitive to metallic impurities, the concentration of the corresponding chemical elements at least on the second pressure side, preferably in the entire pressure transfer disk, is below the given boundary values as ~~claimed in~~per embodiments of the invention. In the special case of CMOS compatibility the material of the pressure transfer disk is preferably free of the alloying elements Au, Cu, Ag.

A reduction and/or adjustment of a low adhesiveness as ~~claimed in~~per embodiments of the invention can also be achieved, especially in combination with the other measures as ~~claimed in~~per embodiments of the invention, by controlled definition of air channels along the surface, so that the formation of vacuum on the contact area is minimized or prevented. In another embodiment as ~~claimed in~~per embodiments of the invention the leveling disk has a rough surface for the access of gas molecules between the wafer and the leveling disk. As ~~claimed in~~per embodiments of the invention a vacuum between the wafer and the leveling disk is thus prevented by producing a rough surface by the aforementioned methods.

The features described for the pressure transfer disk should also be considered disclosed as features of the described application and vice versa.

An application of the above described pressure transfer disk to bonding, especially thermocompression bonding, is also disclosed as ~~an independent~~another embodiment of the invention.

Other advantages, features and details of the invention will become apparent from the