

Substrate stack, modified layer system, method of handling the substrate stack and device for such a method

The present invention is directed to a substrate stack, a modified layer system, a method
5 of handling the substrate stack and a device for such a method.

In the semiconductor industry, there are countless methods for bonding a product substrate to a carrier substrate. This bond is always necessary if the product substrate needs to be stabilized during at least one method step. Without a suitable carrier substrate, the
10 product substrate would be too fragile and would be damaged or break completely. After the product substrate has been processed accordingly, the product substrate needs to be removed completely and non-destructively from the carrier substrate. In some methods, the product substrate is bonded with its free surface of the product substrate to a second carrier substrate before the first carrier substrate is removed. This allows multiple changes
15 until all sides of the product substrate have been processed accordingly. The method of temporary bonding is called temporary bonding. The separation process is called debonding.

A temporary bond is a bonding method in which two substrates are temporarily bonded
20 with each other so that one of the two substrates can be processed. However, the temporary bond is characterized by the fact that the two substrates can be separated from each other again in a non-destructive manner.

In recent decades, several different methods and devices have been developed to create
25 such a temporary bond. In particular, so-called bonding adhesives, or simply adhesives for short, have been used to create a bond between two substrates. The adhesive was applied to at least one of the two substrates. The adhesive was usually a polymer. In most cases, these were carbon-containing, i.e. organic polymers. These adhesives are characterized by the fact that they create an adhesive bond between the substrates. The substrates do not necessarily have to be flat, but can have elevations. After the temporary
30 bond, the substrates are subjected to pressure and/or heat and are thus temporarily bonded with each other.

Various debonding methods are used to remove the carrier substrate after the product substrate has been processed. One of these debonding methods is the so-called slide-off debonding.

5 In this method, the substrate stack is heated to a temperature at which the viscosity of the adhesive decreases to such an extent that the polymer loses its adhesive properties. Once the desired temperature is reached, a shearing force is applied along the substrate surfaces and the two substrates are sheared off from each other. Shearing is achieved by a shearing movement of the substrate holders to which the substrates are attached.

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Another method is edge-zone debonding. In this method, special carrier substrates are created that only have a high level of adhesion to the adhesive at the edge. The majority of the carrier substrate surface is coated with an anti-sticking layer. The adhesion of the adhesive at the edge is sufficient to process the product substrate without defects. The debond then takes place by destroying the adhesive on the outer edge zone of the carrier substrate. As this zone has a very low thickness, the destruction can take place quickly. Chemical and/or mechanical means are used to destroy the adhesive.

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Another method combines an adhesive with a so-called release layer. The release layer is applied to the carrier substrate and/or the product substrate. Preferably, it is applied to the carrier substrate so as not to contaminate the product substrate with the release layer material. The carrier substrate with the release layer is then bonded to the product substrate using an adhesive. After the product substrate has been processed, a laser, which is preferably focused on the release layer via the carrier substrate side, is used to cause delamination by destroying the release layer. The energy input can be focused and dosed very precisely so that the product substrate is not destroyed. Although this method is regarded as a further development in the state of the art, as the debonding process is immensely simplified by the laser, an adhesive still needs to be used. Temperature stability is therefore still not guaranteed in this method.

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The debonding methods mentioned have the disadvantage that the maximum permitted temperature at which the product substrate is processed must be low. If the product substrate has to undergo a method step that requires a higher temperature, the adhesive strength of the adhesive can drop to such an extent that the product substrate can no longer be fixed to the carrier substrate and is destroyed or breaks completely.

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There are other temporary bonding and debonding methods based on the use of adhesives, which will not be listed in full here.

5 A further development of the temporary bonding method is to use only metallic and/or ceramic layers instead of a polymer-based adhesive. Due to their high temperature stability, the process temperature for the product substrate can be increased immensely. The release layer already known and used in the prior art is retained and is also used in these methods to delaminate the product substrate from the carrier substrate.

10 It is a task of the present invention to improve the bond layers known from the prior art in such a way that they allow additional functionalities which are advantageous when handling the substrate stack in one or more process steps.

The present invention solves the problem with a substrate stack according to claim 1, with
15 a modified layer system according to claim 9, with a method according to claim 10 and with a device for bonding according to claim 14. Advantageous further embodiments of the invention are given in the dependent claims. All combinations of at least two features specified in the description, in the claims and/or in the drawings also fall within the scope of the invention. In the case of stated value ranges, values lying within the stated limits are
20 also to be regarded as disclosed limit values and can be claimed in any combination.

According to a first aspect of the present invention, a substrate stack is provided comprising

- a carrier substrate and
- 25 - a product substrate,

wherein, for a primary function, a modified layer system comprising a layer system material for realizing the primary function is formed between the carrier substrate and the product substrate,

wherein for providing an additional functionality in addition to the primary function, the
30 modified layer system is designed such that at least in some regions an absorption behavior for a region between carrier substrate and product substrate deviates from an absorption behavior which would occur for a complete filling of the region between carrier substrate and product substrate with the layer system material.

35 Compared to the layer systems known from the prior art, the invention provides that the layer system has an additional function in addition to the primary function. The primary

function is, for example, the formation of a bond between the product substrate and the carrier substrate, in particular a bond, most preferably a temporary bond between the product substrate and the carrier substrate, or the possibility of simple debonding, in particular by means of a Laser, in which the carrier substrate and the product substrate are initially bonded with each other via the layer system. The additional function makes it possible, for example, to prepare or modify the layer system in such a way that it can for example support an alignment process or improve a debonding process. As a result, the layer system proves to be advantageous as it provides, for example, other additional functionalities, in particular independent of the layer system material used and its optical absorption behavior, which would otherwise have to be realized in a different way at great expense. The invention is therefore most preferably characterized by the multifunctional layer system.

In the further course of the text, a product substrate can also be understood as a set of layers that are created directly, in particular without a bonding process, on the layer system of the carrier substrate by several different methods, in particular at least one epitaxial method. Preferably, the modified layer system and/or the product substrate is in each case a part of several layers formed, for example, by an epitaxial method for forming the substrate stack. For example, the product substrate and the layer system each comprise several layers that have been applied to or formed on the carrier substrate, in particular.

It is most preferably provided that the bonding is a temporary bonding. The uppermost layer of the layer system, which acts as a bond layer, has in particular an adhesive character, which is designed in particular for temporary bonding. It is more preferably provided that the carrier substrate is thicker than the product substrate in order to ensure corresponding stability. Furthermore, it is more preferably provided that the region with the changed absorption behavior is surrounded, in particular completely, by layer system material, in particular in a plane running parallel to the main extension plane, and/or that a reduced amount of layer system material is formed in the region with the changed absorption behavior. In particular, the layer system material is understood to be the material that is used to perform the primary function, for example for bonding and/or separating the carrier substrate and the product substrate. The layer system can also comprise further elements, for example further layers or coatings, which are not part of the layer system material but which cause the additional functionality. The layer system material is determined by the primary function. If bonding is meant as the primary function, the layer system ma-

material has to be the material that is responsible for the bonding. If the layer system provides another material, this determines an additional functionality and is not assigned to the layer system material that is assigned to the primary function. This also applies to material layers that have been added to reinforce the primary function.

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In particular, the additional functionality is a functionality that is related to the optical absorption behavior, e.g. uses the modified optical absorption behavior for a specific function. Preferably, the additional function uses the absorption behavior or is a result of the absorption behavior. For example, light is specifically absorbed and/or transmitted in the region with the changed absorption behavior in order to use this functionality. In summary, it is therefore more preferably an additional optical function.

The absorption behavior is more preferably to be understood as an absorption spectrum. Such an absorption spectrum can be characterized, for example, by the fact that light is absorbed and/or transmitted depending on the wavelength. A change in the absorption behavior occurs in particular if, for example, an absorption capacity decreases and/or increases for a certain wavelength. In the present case, it is provided that the absorption behavior, in particular the absorption spectrum, which occurs when only layer system material is provided in an observed subregion of the layer system between the product substrate and the carrier substrate is used as a reference. This makes it advantageously possible to reduce the absorption behavior by a corresponding spatial modulation or a reduction of the layer system in such a way that the effective optical path length through the layer system material is reduced. This allows local transparency to be created as an additional functionality.

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According to a preferred embodiment of the present invention, it is provided that a material distribution of the layer system material in the layer system is at least temporarily spatially modeled. Preferably, the material distribution of the layer system material is designed to be permanent, i.e. at least during the period in which the bond is present between the product substrate and the carrier substrate. For example, this can be realized by forming transparent regions within the layer system, for example by providing a void region and/or embedding a transparent material for a certain wavelength in the region in the layer system, which otherwise essentially consists of the layer system material.

Preferably, it is provided that the layer system has at least one transparent region, in particular a void region. In particular, material can be specifically removed or detached from

defined regions before bonding the product substrate and carrier substrate in order to ensure a corresponding void region that allows alignment to be carried out using alignment markers on the product substrate, in particular in the case of a transparent carrier substrate. The transparent region advantageously forms a window-like region that allows visual detection of the product substrate and in particular of the alignment markers on the product substrate if the visual detection, for example by a camera or by the human eye, is directed to the side of the substrate stack on which the carrier substrate extends. For example, the layer system of can also be provided as a single layer, the primary function of which is to create a bond.

The window-like region is preferably square. The dimensions of the window-like region are between $50\text{ }\mu\text{m} \times 50\text{ }\mu\text{m}$ and $500\text{ }\mu\text{m} \times 500\text{ }\mu\text{m}$, preferably between $100\text{ }\mu\text{m} \times 100\text{ }\mu\text{m}$ and $200\text{ }\mu\text{m} \times 200\text{ }\mu\text{m}$. Non-square, rectangular window-like areas are also conceivable, for example in the region between $40\text{ }\mu\text{m} \times 200\text{ }\mu\text{m}$.

Preferably, it is provided that the layer system has an alignment marker in and/or on at least one of its layers, in particular if the layer system is formed by several layers. This makes it advantageously possible to specifically align a product substrate, in particular a product substrate with structures, relative to the alignment marker in the layer system. The alignment marker is made of a material that deviates from the material of the layer in and/or on which the alignment marker was created, which in turn modifies the absorption behavior in the region of the assembly of the alignment marker compared to an absorption behavior that occurs when the layer system in this region consists entirely of layer system material. This gives the bond layer an additional function. The layer system material does not include alignment markers or intermediate layers that are provided in addition to the layer system material.

In particular, it is provided that the layer system comprises layer system material and intermediate layers, preferably as dielectric layers, for frequency-selective influencing of the absorption behavior. Preferably, it is provided that the layer system is formed from different, in particular alternating, layers or individual layers in order to influence the absorption behavior of the layer system in a frequency-selective manner. This makes it possible in an advantageous way to influence the absorption behavior in the bond layer in a frequency-selective manner by a targeted layer arrangement, in particular by an alternating layer arrangement of layer system material of different, in particular alternating materials. This proves to be particularly advantageous if an absorption capacity for certain defined laser

wavelengths is to be increased in a targeted manner. This makes it possible, for example, for laser light to be specifically absorbed only in a release layer and/or bond layer in order to trigger a debonding process through the locally created heat input. In particular, the individual layers of the layer system interact and/or are arranged in relation to each other in such a way that absorptions can be specifically increased due to interferometric effects or overlapping. Preferably, some layers of the layer system are comparatively thin metal layers. However, a combination of metal and non-metal layers is also conceivable.

In a further preferred embodiment, it is provided that the layer system is closed along a main extension plane and preferably the absorption behavior is spatially constant over the entire region between the carrier substrate and the product substrate. This can preferably ensure that a bonding and a subsequent debonding process can act effectively over the entire area that contributes to the bonding between the product substrate and the carrier substrate.

Preferably, it is provided that the primary function is a bond, in particular a bonding, between the product substrate and the carrier substrate, wherein the layer system preferably comprises at least one bond layer with a bond layer material. It is particularly provided that the layer system comprises several dielectric layers and/or the layer system material comprises a polymer.

Preferably, it is provided that the light used is laser light. For example, this may be pulsed laser light, in which particularly high energy inputs or powers can be created. The laser light should be absorbed as minimally as possible by the substrates that the laser has to penetrate. Preferably, a wavelength of the laser light is adapted in such a way that the carrier substrate and/or the product substrate is transparent or at least semi-transparent for the wavelength used. The release layer within the layer systems should absorb the laser light to the maximum in order to initiate a debond. Since the substrates are generally much thicker than the layer system, the absorption behavior of the substrate through which the laser is shot is of crucial importance. One example is silicon, the material from which most substrates in the semiconductor industry are made.

If the carrier substrate or the product substrate is a silicon substrate, then the wavelength of the laser should be between 1 μm and 10 μm , as silicon has a very high transmittance, in other words permeability, of up to 50% in this wavelength range. If other substrates are selected, it may be necessary to choose a Laser with a different wavelength.

In particular, it is provided that laser light, in particular pulsed laser light, is used for separating. In a preferred embodiment of the method, it is provided that the laser beams have a wavelength between 0.1 μm and 500 μm , preferably between 0.2 μm and 100 μm , more preferably between 0.3 μm and 50 μm , most preferably between 0.5 μm and 10 μm , utmost preferably between 1 μm and 2.5 μm . In this way, the separation layer can be irradiated in a particularly efficient and targeted manner. The carrier substrate is preferably permeable to the laser beams.

10 In a preferred embodiment of the method, it is provided that the pulse energy of the laser beams is between 0.01 μJ and 128 μJ , preferably between 0.125 μJ and 64 μJ , more preferably between 0.25 μJ and 32 μJ , most preferably between 0.5 μJ and 16 μJ , utmost preferably between 1 μJ and 8 μJ . It turned out that damage to the product substrate can be avoided with these pulse energies. In a preferred embodiment of the method, it is provided that the pulse duration of the laser beams is between 10,000 ps and 1 ps, preferably between 1,000 ps and 1 ps, even more preferably between 500 ps and 1 ps, most preferably between 100 ps and 1 ps, utmost preferably between 50 ps and 1 ps. This pulse duration allows targeted action for separation.

20 A further subject of the present invention is a modified layer system for a substrate stack according to the invention, wherein at least one layer comprises, more preferably consists of, a ceramic material. All the advantages and properties described for the substrate stack apply analogously to the layer system. In particular, a layer system is understood to be a system whose individual layers are arranged in such a way that they fulfill a special optical task. It is conceivable that the layer system material is provided as such and only needs to be assembled between the product substrate and the carrier substrate. For example, a recess is already provided in the provided layer system, for example in a single-layer bond layer, to form a transparent region into which either a component made of another material can be filled and/or which is already inserted and/or which remains permanently void.

30 The layer system preferably comprises at least one layer. Preferably, all layers of the layer system are hard material layers, in particular metallic and/or ceramic layers. However, the use of at least one polymer layer, in particular an adhesive, is also conceivable. The layers used to form the layer system are preferably a layer of one of the following material classes

- Dielectric medium, in particular

- Nitride, in particular
 - TiN, CrN, TaN, AlN, NiN, Si₃N₄
 - Carbide, in particular carbon layers
 - Oxide
- 5 ○ less preferably polymer
- Electric medium, preferably
 - Metal, in particular
 - Cr, Al, Ta, Co, Ni, Mn, Fe, Au, Ga, Sn, Ge, W, Cu, In

10 The layer system is modified, for example, in at least one of the ways described below.

In a first embodiment, the layer system has transparent regions to allow back side alignment of the product substrate. The transparent regions allow the product substrate surface, which is bonded to the carrier substrate surface via the layer system, to be seen
 15 through the carrier substrate. This enables alignment of the product substrate fixed to the carrier substrate with another product substrate. The prerequisite for this is the transparency of the carrier substrate for the wavelength used. The carrier substrate must not have any absorbing layers or regions.

20 A transparent region is understood to be a subsection within the layer system through which measurement is possible. The transparent regions can therefore consist of a material that is transparent to electromagnetic radiation. However, it is also conceivable that the transparent regions are a solid-free volume element within the layer system, i.e. regions in which no material is present. The transparency would then refer to the vacuum or
 25 an enclosed gas or gas mixture, in particular the atmosphere.

In a second embodiment, the layer system has alignment markers which can be used to position a substrate and/or at least one die and/or chip. It is also conceivable, for example, that in a multi-layer layer system, the alignment marker is arranged between two layers of
 30 the layer system. The dies are either created directly in a product substrate or are cast in a casting compound to form a chip. The casting compound then forms the product substrate together with the molded chips. The dies and/or chips have alignment markers. By using an optical system, the alignment markers on the dies and/or chips and the layer system can be observed simultaneously. In this case, at least one layer of the layer system
 35 acts as an alignment marker layer.

A further aspect of the present invention is a method for handling a substrate stack according to the invention comprising a carrier substrate, a product substrate and a layer system, wherein the layer system is arranged between the carrier substrate and the product substrate. All the advantages and properties described for the substrate stack can be transferred analogously to the method and vice versa. By forming a corresponding layer system in the substrate stack, it is advantageously possible to ensure additional functions and functionalities in the further manufacturing process and/or handling process of the substrate stack, which simplify the further process. For example, it is conceivable that an alignment of the product substrate with respect to another product substrate is simplified or that a debonding process is simplified or that a bonding process with another product stack can be supported.

Preferably, it is provided that light is directed onto the substrate stack. This also applies in particular if, for example, an alignment marker is recorded or detected using a corresponding optical system, such as a corresponding camera system. For this purpose, it is necessary that the corresponding alignment marker is illuminated with a corresponding light source. It is preferably provided that light, in particular laser light, is directed onto the layer system for targeted absorption of the layer system, most preferably focused on the bonding layer.

Preferably, it is provided that the light is transmitted through void regions in the layer system for the alignment of a structural element or another product substrate. This makes it advantageously possible to also use such layer system materials that would otherwise prevent light from being transmitted through the layer system due to their usual absorption behavior. Due to a corresponding window-like transparent region, it is already possible to realise alignment markers on the product substrate even from the side on which the carrier substrate is arranged. In other words, alignment markers can also be realised through the corresponding transparent regions when looking at the product substrate from the direction of the carrier substrate or when trying to detect it visually in the corresponding direction, for example using an optical system, in particular a camera system.

If infrared light is used for observation through silicon, it may be advantageous to select infrared light with a wavelength of approximately 1 μm to increase the contrast between silicon and non-silicon areas.

Preferably, light is provided to be absorbed by the carrier substrate and product substrate for debonding. This makes it advantageously possible to trigger the debonding process between the product substrate and the carrier substrate, in particular when further bond between the product substrate and the carrier substrate is no longer desired. This can be
 5 induced by illuminating with light of the corresponding wavelength and in particular with an intensity above a threshold intensity.

A further aspect of the present invention is a device for performing a method according to the invention, wherein the device comprises a light source and/or a camera. By using a
 10 light source and/or a camera accordingly, the changed absorption behavior in particular can be used in order to realize or be able to use a corresponding additional functionality. All the advantages and properties described for the substrate stack and the method can be transferred analogously to the device.

15 Most preferably, it is provided that the light source is adapted to the layer system. In particular, it is provided that a wavelength, for example of a laser light, is matched to the absorption or an absorption behavior of the bond and/or release layer of the layer system.

Further advantages, features and details of the invention are apparent from the following
 20 description of preferred embodiments and from the drawings. They show in:

- Figure 1** a side view of a substrate stack with a first bond layer according to the invention,
- 25 **Figure 2** a side view of a method step of a face-to-face method,
- Figure 3** a side view of a method step of a face-to-face method,
- Figure 4** a side view of a method step of a face-to-back method,
 30 **Figure 5** a side view of a method step of a face-to-back method,
- Figure 6** a side view of a method step of a back-to-back method,
- 35 **Figure 7** a side view of a method step of a back-to-face method,

Figure 8 a side view of a bonded substrate stack,

Figure 9 a side view of a debonding process and

5 **Figure 10** a side view of a substrate stack with a second bond layer according to the invention

Figure 11 a special embodiment example of a layer system and

10 **Figure 12** another way of using the layer system 2

In the figures, identical components or components with the same function are indicated with the same reference signs.

15 The following figures show simplified side views of a method step of an alignment process. For the sake of clarity, the finding of the alignment markers with the help of an optical sub-device is only shown on the right-hand side (see Figures 2 to 7). In general, a corresponding optical sub-device is also located on the left-hand side of a corresponding alignment device. Possible alignment devices are described in detail in the publications
 20 US 6,214,692 B1, US 10,692, 747 B2, US 9,851,645 B2, US 9,418,882 B2 and US 9,576,825 B2. The optical sub-device is represented in simplified form by an upper optic and a lower optic, which are mechanically coupled to one another. Each of the two optics can be aligned with respect to each other by several, ideally six, degrees of freedom. The optics are considered to be calibrated with respect to each other. Corresponding calibration
 25 tion methods are known, for example, from the publications US 9,418,882 B2 and US 9,464,884 B2. Ideally, the optical axes of the two optics are collinear. However, since collinearity is difficult to achieve, the optics are preferably aligned so that their optical axes intersect in a focal region, in particular a focal point. In general, the depth of field of the two optics intersect in said focal area. The measured image of each optic is shown schematically on the left-hand side of each optic, within a circle. In the remainder of the text,
 30 such a measured image is simply referred to as an image.

A face-to-face alignment process is understood to be a method in which the alignment markers 5 are located at the bonding interfaces. A face-to-back or back-to-face alignment
 35 process is a method in which the alignment markers 5 of a first product substrate are located at its bonding interface and the alignment markers of the second product substrate

are located at the product substrate surface opposite the bonding interface. A back-to-back alignment process is a method in which the alignment markers are located exclusively on the product substrate surfaces opposite the bonding interfaces, i.e. the outer product substrate surfaces.

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Furthermore, the second product substrate 3' is always shown as being thick enough so that it does not have to be stabilized by a second carrier substrate 1. However, stabilization of the product substrate 1' by a further carrier substrate 1 is also conceivable.

10 **Figure 1** shows a simplified side view of a substrate stack comprising a carrier substrate 1 with a bond layer 2 and a product substrate 3. The carrier substrate 1 is generally thicker than the product substrate 1 to be stabilized. The product substrate 3 is bonded to the carrier substrate 1 via the layer system 2. The layer system 2 has several transparent regions 4.

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In the other figures, the orientation of two product substrates 3, 3' relative to each other is described. The alignment markers of each product substrate can be located on the product substrate surface that becomes the bonding interface (face alignment) or on the product substrate surface that is opposite the bonding interface (back alignment). Accordingly,
20 there are four possible orientations of the product substrates 3, 3' with respect to each other: face-to-face, face-to-back, back-to-back and back-to-face. Since the layer system 2 is present on the first product substrate 3, the first orientation refers to the first product substrate 3, the second orientation to the second product substrate 3'

25 **Figure 2** shows a simplified, right side view of a method step of a face-to-face alignment process between a first product substrate 3 fixed on a carrier substrate 1 and a second product substrate 3'. The two product substrates 3, 3' and the carrier substrate 1 are transparent in the wavelength range used by the optics 6. The upper optics 6 measures the alignment marker 5 of the upper product substrate 3'. The alignment marker 5 is
30 shown grayish in Figure 7, as the photons that reach the upper optics 6 must pass through the carrier substrate 3', thereby attenuating the intensity, i.e. the number of photons. In the prior art, it would not be possible to measure the alignment marker 5 of the lower product substrate 3, as the layer system 2 would generally be opaque to the wavelength used. Preferably, however, there are transparent regions 4 in the layer system 2
35 that allow a direct view of the alignment markers 5 of the first product substrate 3. Here too, the image 7 of the lower optics 6 shows an attenuated alignment marker 5, as the

photons have to pass through the carrier substrate 1, the transparent region 4 and the product substrate 3. Ideally, at least some parts of the boundary of the transparent region 4 are visible in image 7. The transparent regions 4 may be a material that is transparent to the electromagnetic radiation used. However, it is simpler and preferable to dispense with a separated material altogether, so that the transparent regions 4 are material-free.

Figure 3 shows a simplified, right side view of a method step of a face-to-face alignment process between a first product substrate 3 fixed on a carrier substrate 1 and a second product substrate 3'. The second product substrate 3' and the carrier substrate 1 are transparent, while the first product substrate 3 is opaque. Although the alignment marker 5 on the second product substrate 3 cannot be observed directly from the lower optics 6, the transparent region 4 of the layer system 2 is visible. The transparent region 4 can be seen in image 7 of the lower optics 6. If the orientation relationship between the alignment marker 5 of the first product substrate 3 and the transparent region 4 is known, the transparent region 4 itself can therefore be used as an alignment marker. Such an orientation relationship is very easy to measure by measuring the first product substrate 3 alone with the two optics 6 before the actual alignment process of the two product substrates 3, 3'. The upper optic 6 focuses on the alignment marker 5 of the lower product substrate 3, while at the same time the lower optic 6 focuses on the transparent region 4 of the layer system 2. The two resulting images 7 allow the orientation relationship to be measured.

Figure 4 shows a simplified, right side view of a method step of a face-to-back alignment process between a first product substrate 3 fixed on a carrier substrate 1 and a second product substrate 3'. The upper substrate 6 can directly measure the alignment marker 5 of the second product substrate 3'. The alignment marker 5 appears correspondingly intense in the image 7 of the upper optics 6. The first product substrate 3 is measured in the same way as the lower product substrate 3 of figure 2. The alignment marker 5 of the first product substrate 3, which is visible to the lower optics 6 due to the use of the transparent regions 4 of the layer system 2, and the transparent region 4 are again as well.

Figure 5 shows a simplified, right side view of a method step of a face-to-back alignment process between a first product substrate 3 fixed on a carrier substrate 1 and a second product substrate 3' in which the first product substrate 3 is, however, opaque as well. This embodiment is therefore a combination of Figures 3 and 4.

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Figure 6 shows a simplified, right side view of a method step of a back-to-back alignment process between a first product substrate 3 fixed on a carrier substrate 1 and a second product substrate 3', in which the alignment markers 5 of the first product substrate 3 and the second product substrate 3' are located on the product substrate surfaces opposite the bonding interface. In this embodiment, the transparency of the transparent regions 4 is also utilized in order to be able to observe the alignment marker 5 of the first product substrate 3.

Figure 7 shows a simplified, right side view of a method step of a back-to-face alignment process between a first product substrate 3 fixed on a carrier substrate 1 and a second product substrate 3', in which the alignment marker 5 of the first product substrate 3 is located on the product substrate surface facing away from the bonding interface. The alignment marker 5 of the second product substrate 3', on the other hand, is oriented towards the bonding interface. In this embodiment, the transparency of the transparent regions 4 is also utilized in order to be able to observe the alignment marker.

Figure 8 shows a simplified, side view of two product substrates 3, 3' bonded to each other. The lower product substrate 3 is still fixed to the carrier substrate 1 via the layer system 2. However, due to the bond created between the two product substrates 3, 3', the resulting product substrate stack is much more stable and the carrier substrate 1 can be removed if necessary. However, it is conceivable that the product substrate 3' could be processed again and several further product substrates 3'', 3''' (not shown) are bonded to this system. This would then result in a multi-product substrate stack.

Figure 9 shows a simplified, side view of a debonding process. The debonding process is carried out with the help of a laser 8. The carrier substrate 1 must be transparent to the laser beam used by the laser 8. On the other hand, the layer system 2 must have the highest possible absorption for the photons of the Laser 8 in order to enable the delamination, the debond. The layer system 2 consists of at least one release layer, which is subject to ablation by the Laser 8. If the release layer is the only layer of the layer system 2, it is also a bond layer. However, it is also conceivable that the layer system 2 consists of several layers. It is conceivable, for example, that a release layer has been applied to the carrier substrate 1, on which an oxide layer has been separated. In this case, the layer system 2 would consist of a release layer and an oxide layer. The oxide layer would act as a bond layer, while the release layer would be used exclusively for the debonding process.

It is also conceivable that the method steps shown are performed with two product substrates 3, each of which has been bonded to a separate carrier substrate 1. In this case, the layer system 2 according to the invention would be present on both carrier substrates 1 and could advantageously be used on both carrier substrates 1.

Figure 10 shows a simplified, side view of a carrier substrate 1 on which a further, second embodiment of the layer system 2 has been made. In this case, the layer system 2 has alignment markers 5. Furthermore, a product substrate 3 is shown which has several structures, in particular functional units, most preferably chips 9, which also have corresponding further alignment markers 5'. The first product substrate 3 must be transparent to an optical system 6 so that the alignment markers 5 of the layer system 2 and the alignment markers 5' of the chips 9 in the product substrate 3 can be detected simultaneously. It is conceivable that the chips 9 were manufactured directly in the product substrate 3. The product substrate 3 is then silicon, for example, and infrared light is used for observation and measurement. It is also conceivable that the product substrate 3 is a casting compound that was used to cast the chips 4. In this case, a casting compound would have to be used that is transparent to the used electromagnetic radiation. Figure 7 of the optics 6 shows that the alignment marker 5' is not located on the horizontal line shown. It is conceivable that both alignment markers 5, 5' must be located on this line. Accordingly, the lower carrier substrate and/or the upper product substrate 3 could be shifted accordingly. The person skilled in the art will understand that in this particular case, the aim will be to optimally align all chips 9 to the bond layer 2, which requires observation of several positions.

Figure 11 shows a specific embodiment example of a layer system 2 which is conceivable for forming a substrate stack according to an exemplary embodiment of the present invention. While the embodiment examples of Figures 1 to 10 have essentially been devoted to the optical detection of alignment markers by transparent regions in the layer system 2 or the optical detection of alignment markers in the layer system 2, the layer system 2 is defined by its layer position such that it has a special transmission and absorption capability. For this purpose, it is provided that the layer system 2 has alternating layers that influence the transmission and absorption behavior of electromagnetic radiation. Preferably, this involves several layers 10. Due to the corresponding spacing, preferably equidistant assembly of the layers 10, it is advantageously possible to influence frequency-selectively on the

absorption behavior. This in turn makes it advantageously possible to increase the absorption for certain wavelengths compared to other wavelengths. As a result, the absorption can be specifically optimized for a wavelength for which, for example, the carrier substrate is transparent. Due to the increased absorption in the layer system 2, it is then possible to cancel the bond functionality, i.e. the main functionality, due to the energy input, which allows a corresponding debonding process. By specifically setting an increased absorption for a certain wavelength, a corresponding energy effort for debonding can thus be reduced in an advantageous way, in particular because the energy transfer to the bond layer can be optimized and made more efficient. Alternatively or additionally, it is conceivable that material is added to the layer system material whose absorption behavior is increased for a certain wavelength.

Figure 12 shows another way of using the layer system 2. A layer system 2 is separated on a carrier substrate 1. In the present case, the layer system 2 consists of a release layer 11 and a seed layer 12. It is also conceivable, for example, to additionally provide the layer system 2 with the layers 10, 10' according to Fig. 11 in order to achieve a corresponding transmission or absorption effect. For the sake of simplicity, however, only one release layer 11 is shown. The seed layer 12 serves as a starting point for the creation of an epitaxial layer 13. In general, the production of such an epitaxial layer 13 is complicated and must be created by several method steps, in particular by creating several further layers. A very frequently used method is the creation of an epitaxial layer 13 by overgrowth. For the sake of clarity, the exact layer structure is omitted. Only an epitaxial layer 13 on a layer system 2, in particular on the seed layer 12, is shown. Functional units can now be created in this, in particular very thin, epitaxial layer 13. By laser strating of the release layer 11, the seed layer 12 with the epitaxial layer 13 can be released from the carrier substrate 11. In general, the epitaxial layer 13 is previously bonded with its surface to another substrate (not shown) . However, it is also conceivable that the epitaxial layer 13 is removed directly from the carrier substrate 1 and fixed, in particular on a film carrier. Figure 12 shows that a layer system 2 according to the invention does not necessarily have to be bonded with a bonding process. The epitaxial layer created in this way can then also be regarded as a product substrate in the meaning of the invention.

Reference list:

5	1	Carrier substrate
	2	Layer system
	3, 3'	Product substrate
	4	Transparent region
	5	Alignment marker
10	6	Optics
	7	Image
	8	Laser
	9	Chip
	10	Layers
15	11	Release layer
	12	Seed layer
	13	Epitaxial layer

Claims

1. A substrate stack comprising
 - a carrier substrate (1) and
 - 5 - a product substrate (3),wherein, for a primary function, a modified layer system (2) comprising a layer system material for realizing the primary function is formed between the carrier substrate (1) and the product substrate (3),
wherein for providing an additional functionality in addition to the primary func-
10 tion, the layer system (2) is designed such that at least in some regions an absorption behavior for a region between carrier substrate (1) and product substrate (3) deviates from an absorption behavior which would occur for a complete filling of the region between carrier substrate (1) and product substrate (3) with the layer system material.
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2. Substrate stack according to claim 1, wherein a material distribution of the layer system material in the layer system (2) is at least temporarily spatially modulated, preferably along a main extension plane and/or along a direction extending perpendicular to the main extension plane.
20
3. Substrate stack according to one of the preceding claims, wherein the layer system (2) comprises at least one transparent region (4), in particular a void region.
- 25 4. Substrate stack according to one of the preceding claims, wherein the layer system (2) comprises an alignment marker (5).
5. Substrate stack according to one of the preceding claims, wherein for a frequency-selective influence on the absorption behavior the layer system (2)
30 comprises layer system material and intermediate layers (12), preferably as dielectric layers.
6. Substrate stack according to claim 5, wherein the layer system (2) is closed along a main extension plane and preferably the absorption behavior is spatially constant over the entire region between carrier substrate (1) and product
35 substrate (3).

7. Layer system according to one of the preceding claims, wherein the primary function is a connection, in particular a bond, between the product substrate (3) and the carrier substrate (1), wherein the layer system (2) preferably comprises at least one bond layer with a bond layer material.
- 5 8. Substrate stack according to one of the preceding claims, wherein the layer system (2) comprises several dielectric layers and/or the layer system material comprises a polymer.
- 10 9. A modified layer system (2) for a substrate stack according to one of the preceding claims, wherein a layer system material for the bond layer (2) preferably comprises a ceramic material.
- 15 10. A method for handling a temporary bond of a substrate stack with a carrier substrate (1), a product substrate (3) and a bonding layer (2) according to one of the preceding claims, wherein the bonding layer (2) is arranged between the carrier substrate (1) and the product substrate (3)
- 20 11. Method according to claim 10 according to one of the preceding claims, wherein light is directed onto the substrate stack.
- 25 12. Method according to claim 10 or 11, wherein the light is transmitted through void regions (4) in the bond layer (2) for alignment of a structural element (5, 5') or a further product substrate.
- 30 13. Method according to one of claims 10 to 12, wherein light is absorbed for debonding the carrier substrate and the product substrate.
- 35 14. Method according to one of claims 10 to 13, wherein a gas bubble (13) is created in the region of the bond layer, the gas bubble (13) preferably deforms the product substrate (3) at least regionally.
15. A device for performing a method according to one of claims 10 to 14, wherein the device comprises a light source and/or a camera.