Device and Method for Alignment of substrates

Specification

This invention relates to a method for alignment and contact-making of a first substrate with a second substrate and a corresponding device.

In the semiconductor industry substrates have been joined to one another for years. It is generally necessary to align the substrates to one another before the actual joining process, bonding. The substrates are aligned to one another with alignment systems. The alignment systems are able to detect alignment marks on the substrates and to align the substrates to one another such that the alignment marks complement one another accordingly. In most cases the alignment marks are complementary to one another.

In order to correctly align two substrates to one another, at least four alignment marks, two on each substrate, are necessary. The alignment marks are preferably as near as possible to the edge of the substrate in order to increase the alignment accuracy.

In an alignment process it is always distinguished between the boundary layer surface and the surface of a substrate which is opposite the boundary layer surface. The boundary layer surface is the surface of the substrate which later becomes part of the bond boundary surface. An alignment mark which is located on a boundary layer surface is called a face-side alignment mark, an alignment mark on the correspondingly opposite side is called a back-side alignment mark. Accordingly there are four basic alignment versions, back-to-back, face-to-face, face-to-back and back-to-face alignments.

In back-to-back alignment no serious problems arise since the alignment marks are actually always on surfaces which are freely accessible to all optics, pointed to the outside.

One special challenge in alignment technology is the face-to-face version. In this alignment version the alignment marks are always aligned to the bond boundary surface, therefore the plane between the two substrates. One possibility is transmission detection, transmission measurement and transmission alignment which are only used when all layers on the substrate, including the substrate itself, are transparent to the electromagnetic waves of the electromagnetic spectrum used at the time. This is not always the case for IR radiation and visible light.

The alignment system in patent AT 405775B follows another, third approach. This patent shows that it is possible to cause the front surfaces of the two substrates which are to be aligned to one another to approach one another almost to contact. The upper and the lower substrate are fixed by corresponding sample holders on an upper and lower carriage and can move in translation, on alternate sides out of the alignment station into a measurement station, in which the respective x and y positions of the alignment marks which are the left or right at the time on the respectively upper and lower substrate can be correctly measured. The advantage in patent AT 405775B is mainly that the substrates before and during the alignment process have an extremely small spacing

in the z direction, and therefore when the two substrates approach one another they must also only more traverse one very short path in the z direction in order to be brought into contact with one another. On this extremely short path the deviation from the desired alignment accuracy in the x and y direction is hardly of any more importance.

One of the most serious technical problems is the positioning faults which arise by the movement of the substrates and which can occur especially in an environment which can be evacuated. Under these conditions air bearings can no longer be used, with which actually a frictionless sliding of the carriages should be ensured.

Embodiments of this invention disclose a device and a method for alignment and contact-making of substrates, with which more accurate and more efficient alignment and contact-making of substrates are enabled.

According to a first aspect of the present invention, there is provided a method for alignment and contact-making of a first substrate with a second substrate, the method including: fixing the first substrate on a first mount and fixing the second substrate on a second mount which is located opposite the first mount, wherein the first and second substrate are located between the first and second mount with a distance A between a first contact surface of the first substrate and a second contact surface of the second substrate in the Z direction, moving the first mount to a first detection unit in a first detection position and moving the second mount to a second detection unit in a second detection position opposite to the first detection position, detecting a first X-Y position of a first alignment marking located in a peripheral region of the first substrate in the first detection position which has moved in an X and/or Y direction along the first contact surface, detecting a second X-Y position of a second alignment marking located in a peripheral region of the second substrate in the second detection position which has moved in an X and/or Y direction along the second contact surface, moving the first mount to the second detection unit in the second detection position and the second mount to the first detection unit in the first detection position, detecting a third X-Y position of a third alignment marking located in a peripheral region of the first substrate in the second detection position, detecting a fourth X-Y position of a fourth alignment marking located in a peripheral region of the second substrate in the first detection position, aligning the first substrate relative to the second substrate by adjustment units based on the first, second, third and fourth X-Y positions which have been detected by the detections, and contacting the first substrate, which has been aligned relative to the second substrate, with the second substrate.

According to a second aspect of the present invention, there is provided a device for aligning and contact-making of a first substrate with a second substrate, the device including: a first mount for fixing of the first substrate and a second mount located opposite the first mount for fixing of the second substrate, wherein the first and the second substrate are locatable between the first and second mount with a distance between a first contact surface of the first substrate and a second contact surface of the second substrate in a Z direction, a first adjustment

unit for moving the first mount at least in one X direction and/or Y direction which runs transversely to the Z direction, a second adjustment unit for moving the second mount at least in one X direction and/or Y direction, detection means for: a) detecting a first X-Y position of a first alignment marking located in a peripheral region of the first substrate in a first detection position which has moved in a X and/or Y direction along a first contact surface, b) detecting a second X-Y position of a second alignment marking located in a peripheral region of the second substrate in a second detection position which has moved in an X and/or Y direction along the second contact surface, c) detecting a third X-Y position of a third alignment marking located in a peripheral region of the first substrate in the second detection position, d) detecting a fourth X-Y position of a fourth alignment marking located in a peripheral region of the second substrate in the first detection position, wherein the detection means are provided such that visible light is usable for detecting the positions, adjustment units for aligning the first substrate relative to the second substrate based on the first, second, third and fourth X-Y positions which have been detected by the detection means, and contact-making means for contacting the first substrate, which has been aligned relative to the second substrate, with the second substrate in the Z-direction, wherein the device is operable to detect the alignment markings on bonding surfaces by opposed parallel displacement of the substrates to: move the first mount to a first detection unit in a first detection position and move the second mount to a second detection unit in a second detection position opposite to the first detection position, and move the first mount to the second detection unit in the second detection position and move the second mount to the first detection unit in the first detection position.

All combinations of at least two of the features given in the specification, the claims and/or in the figures fall within the scope of the invention. For given values ranges, values which lie within the indicated limits should be considered disclosed as boundary values and able to be claimed in any combination.

Embodiments of the invention are based on the idea, especially by providing several detection positions outside of the alignment position, of detecting the relative positions of two substrates to one another with the minimal travel paths of the substrate, preferably without changing a distance A between the substrates during the detection, after detection, contact-making taking place solely by movement of the substrates in the z direction (therefore towards one another). The distance A between the substrates is minimum as much as possible, without moving detection means between the substrates in a detection of features on the substrates, preferably of alignment marks, in one detection position. Thus both the travel paths in the X and Y direction during detection and alignment as well as the travel paths in the Z direction after alignment up to contact-making can be minimized.

The embodiments of the invention show mainly a new and inventive apparatus with which the alignment and contact-making of substrates for the first time is possible with high