Device and Method for Bonding of Substrates

This invention relates to a method for bonding of a first substrate to a second substrate and a corresponding device.

Advancing miniaturization in almost all parts of microelectronics and microsystems engineering provides for a continuing development of all technologies using which the density of all type of functional units on substrates can increase. These functional units include for example microcontrollers, memory components, MEMS, all type of sensors or microfluid components.

Techniques for increasing the lateral density of these functional units have greatly improved in recent years. In some branches of microelectronics or microsystems engineering even so far that a further increase of the lateral density of the functional units is no longer possible. In microchip production the maximum achievable resolution limit for structures which are to be produced lithographically has been as good as achieved. In a few years physical or technological limitations therefore will no longer allow any increase in the lateral density of functional units. The industry has been addressing this problem for some years by the development of 2.5D and 3D technologies. Using these technologies it is possible to align the same or even different types of functional units to one another, stack them on top of one another, join them permanently to one another and to network them to one another by corresponding printed circuits.

One of the key technologies for the implementation of these structures is permanent bonding. Permanent bonding is defined as all methods using which substrates can be joined to one

this way the lower substrate is not subjected to boundary conditions and can bond freely to the upper substrate during the bonding process. An important feature in the prior art is primarily the flat fixing of a substrate, generally by means of a vacuum device.

The run-out faults which arise are more dramatic in most cases radially symmetrically around the contact site, therefore increase from the contact site to the periphery. In most cases it is a linearly increasing intensification of the run-out faults. Under special conditions the run-out faults can also increase nonlinearly.

Under especially optimum conditions the run-out faults can be determined not only by corresponding measuring devices (EP2463892), but can also be described by mathematical functions. Since the run-out faults constitute translations and/or rotations and/or scalings between well defined points, they are preferably described by vector functions. Generally this vector function is a function $f:R^2 \rightarrow R^2$, therefore am imaging standard which images the two-dimensional definition region of the local coordinates onto the two- dimensional value range of run-out vectors. Although an exact mathematical analysis of the corresponding vector fields could not be done, assumptions are made with respect to the function properties. The vector functions are with great probability c^n $n>=1$ functions, therefore they are continuously differentiable at least once. Since the run-out faults increase from the contact-making point toward the edge, the divergence of the vector function will probably be different from zero. The vector field is therefore with great probability a source field.

Embodiments of this invention provide a device and a method for bonding of two substrates with which the bond precision, especially on the edge of the substrates, is increased.

According to a first aspect of the present invention, there is provided a method for bonding a first substrate to a second substrate on contact surfaces of the substrates, the method including the steps of: accommodating the first substrate on a first mounting surface of a first mounting apparatus and accommodating the second substrate on a second mounting surface of a second mounting apparatus, contact-making of the contact surfaces at a bond initiation site, bonding the first substrate to the second substrate along a bonding wave which is travelling from the bond initiation site to the side edges of the substrates, wherein the bonding wave is controlled indirectly via the composition and/or density and/or temperature of a gas in the atmosphere, in which the bonding takes place.

According to a second aspect of the present invention, there is provided a device for bonding of a first substrate to a second substrate on contact surfaces of the substrates, the device including: a first mounting apparatus for accommodating the first substrate on a first mounting surface and a second mounting apparatus for accommodating the second substrate on a second mounting surface, contact means for making contact of the contact surfaces at a bond initiation site, means for bonding the first substrate to the second substrate along a bonding wave which is travelling from the bond initiation site to the side edges of the substrates, wherein the bonding wave is controlled indirectly via the composition and/or density and/or temperature of a gas in the atmosphere, in which the bonding takes place.

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 that at least one of the two substrates, preferably the second and/or lower substrate, is deformed for alignment of the contact surfaces, especially solely, outside the bond initiation site before and/or during the bonding, especially during the travel of a bonding wave, preferably in fusion bonding. Deformation means especially a state which deviates from an initial state, especially initial geometry of the substrates. As per embodiments of the invention the bonding is initiated after contact-making of the contact surfaces especially by allowing the first/upper substrate to fall or by detaching it. Corresponding bonding means are provided especially according to the device.

In the initial state the substrates are generally, especially on one contact surface, more or less flat, aside from any structures which project above the contact surface (microchips, functional components) and substrate tolerance such as bending and/or thickness fluctuations. In the initial state, but in most cases the substrates have a curvature different from zero. For a 300 mm wafer curvatures of less than 50 µm are common. Viewed mathematically, a curvature can be regarded as a measure for the local deviation of a curve from its planar state. In the specific case substrates are examined whose thicknesses are small compared to the diameter. Therefore in a good approximation the curvature of a plane can be addressed. In the case of a plane the initially mentioned flat state is the tangential plane of the curve at the point at which the curvature is being examined. Generally a body, in the special case the substrate, does not have a homogeneous