MARK FIELD, METHOD AND DEVICE FOR DETERMINING POSITIONS

The present invention relates to a mark field, a device for determining X-Y positions of structural features of structures arranged on a substrate and a corresponding method.

In industry, it is of decisive importance to obtain a statement about the position of structures on a substrate. The difference between the real actual position and the ideal desired position of a structure is of particular interest. In order to determine the actual positions of structures, one can introduce a coordinate system and specify the position of the structures in relation to this coordinate system. For the most part, this is a body-fixed coordinate system, i.e. a coordinate system assigned to the substrate. The coordinate system is termed a substrate coordinate system in the remainder of the document.

However, in order to be able to measure all structures, a relative movement must take place between the substrate and the measurement system, particularly an optical system with a camera. That is necessary, as not all structures are located in the viewing area of the measurement system. Were all of the structures to be measured located in the viewing area of the measurement system, a relative movement between the measurement system and the substrate would of course not be necessary.

The relative movement takes place for the most part by means of an active movement of the substrate holder, on which the substrate is fixed, so that the filigrane optical system does not have to be moved. In this case, the position of the substrate holder must be determined very accurately, in order to be able to determine the distances which the substrate holder has covered. The position of the substrate holder must therefore be specified in relation to a spatially fixed coordinate system.

It would also be conceivable to only determine the path of the substrate holder covered between two points. In this case, although a spatially fixed coordinate system is dispensed with, a very precise control system is nonetheless required in order to be able to determine the distances covered very accurately.

Each method from the prior art mentioned requires relatively expensive and complicated electronic-mechanical systems, in order to be able to measure the position or the path covered of the substrate holder and therefore the structural positions on the substrate surface of a substrate. Furthermore, the travel paths of such systems are considerable. Due to the corresponding size, even the smallest temperature fluctuations have an influence on the thermal expansions and thus the component sizes of the components used.

In order to be able to measure structures, which are not simultaneously located in the viewing area of an optical system, on the substrate surface of a substrate, a relative movement must take place between the substrate and the optical system, in order to bring the structures into the viewing area of the optical system one after the other. For the most part, the substrate holder, on which the substrate is fixed, travels, whilst the optical systems are fixed. During the travel, the position of the substrate holder must be followed continuously. One therefore requires a reference system in relation to which the position of the substrate holder is specified. The position information of the substrate holder and thus of the substrate must take place very accurately, particularly in the nanometre range. This exact position information, particularly over travel distances of a plurality of centimetres, requires very accurate and therefore expensive measurement systems, particularly interferometers.

Embodiments of the present invention seek to specify a device and a method for measuring substrates, using which a more accurate and/or more efficient determination of the positions of structures or structural features on substrates is enabled.

According to a first aspect of the present invention, there is provided a mark field for determining positions of structural features of structures arranged on a substrate, the mark field including: at least two location marks with information for the location of the respective location mark in the mark field, and at least one position mark, which is or can be assigned to one of the location marks, wherein the location mark is an encoded mark and the position mark is associated with the location mark, wherein the mark field is located on a substrate holder on which the substrate is fixed, and wherein at least one of the two location marks and the at least one position mark are optically measurable and configured to be simultaneously optically detectable within a predefined viewing area of an optical system.

According to a second aspect of the present invention, there is provided a device for determining X-Y positions of structural features of structures arranged on a substrate, the device including: a substrate holder; and a plurality of optical systems, wherein the device is configured to determine the X-Y positions relative to a mark field affixed to the mark field carrier and fixed with respect to the substrate, the mark field including: at least two location marks with information for the location of the respective location mark in the mark field, and at least one position mark, which is or can be assigned to one of the at least two location marks, wherein the location mark is an encoded mark and the position mark is associated with the location mark, wherein the mark field is located on a substrate holder on which the substrate is fixed, and wherein at least one of the two location marks and the

at least one position mark are optically measurable, the optical systems configured to simultaneously optically detect both the at least one of the two location mark and the at least one position mark within a predefined viewing area.

According to a third aspect of the present invention, there is provided a method for determining X-Y positions of structural features of structures arranged on a substrate, wherein the X-Y positions are determined relatively to a mark field fixed with respect to the substrate, the method including: providing at least two location marks with information for the location of the respective location mark in the mark field, providing at least one position mark, which is or can be assigned to one of the at least two location marks, wherein the location mark is an encoded mark and, the position mark associated with the location mark, locating the mark field on a substrate holder on which the substrate is fixed by simultaneously optically detecting at least one of the two location marks and the at least one position mark within a predefined viewing area of an optical system.

All combinations made up of at least two features specified in the description, the claims and/or the figures also fall within the scope of the invention. When value ranges are specified, values lying within the limits mentioned should also be disclosed as limit values and be claimable in any desired combination.

Embodiments of the invention are based on the idea of providing a mark field having

- at least two location marks with information for the location of the respective location mark in the mark field, and
- at least one position mark, which is or can be assigned to one of the location marks, for determining X-Y positions of structural features of structures on a substrate, particularly independently of a movement or position of a substrate holder.

The measurement according to embodiments of the invention of the structures of a substrate in further process steps in particular allows a more accurate and more efficient bonding process of two substrates to one another. If the measured structural positions do not correspond to the desired structural positions, a compensation of at least one of the two substrates takes place in particular prior to and/or during the bonding process.

In other words, substrate pairs are preferably formed according to selection criteria.

CLAIMS:

1. A mark field (4) for determining positions of structural features (11c) of structures (11) arranged on a substrate (7), the mark field (4) comprising:
   - at least two location marks (2) with information for the location of the respective location mark (2) in the mark field (4), and
   - at least one position mark (3), which is or can be assigned to one of the location marks (2),

   wherein the location mark (2) is an encoded mark and the position mark (3) is associated with the location mark (2),

   wherein the mark field (4) is located on a substrate holder (8) on which the substrate (7) is fixed, and

   wherein at least one of the two location marks (2) and the at least one position mark (3) are optically measurable and configured to be simultaneously optically detectable within a predefined viewing area of an optical system (13).

2. The mark field (4) according to claim 1, wherein the location marks (2) and/or position marks (3) are arranged in a matrix with uniform spacings between the location marks (2) and/or position marks (3).

3. The mark field (4) according to claim 2, wherein the matrix is a symmetrical matrix.

4. The mark field (4) according to one or more of claims 1 to 3, wherein adjacent location marks (2) and/or adjacent position marks (3) are arranged on the mark field (4).

5. The mark field (4) according to claim 4, wherein the adjacent location marks (2) and/or the adjacent position marks (3) are arranged equidistantly on the mark field (4).

6. The mark field (4) according to one or more of claims 1 to 5, wherein the mark field (4) has at least 10 x 10 marks (1), wherein the marks (1) comprise the location marks (2) and the position marks (4).

7. The mark field (4) according to one or more of claims 1 to 5, wherein the mark field (4) has at least 100 x 100 marks (1), wherein the marks (1) comprise the location marks (2) and the position marks (3).

8. The mark field (4) according to one or more of claims 1 to 5, wherein the mark field (4) has at least 1000 x 1000 marks (1), wherein the marks (1) comprise the location marks (2) and the position marks (4).

9. The mark field (4) according to one or more of claims 1 to 5, wherein the mark field (4) has at least 10000 x 10000 marks (1), wherein the marks (1) comprise the location marks (2) and the position marks (4).

10. The mark field (4) according to one or more of claims 1 to 5, wherein the mark field (4) has at least 100000 x 100000 marks (1), wherein the marks (1) comprise the location marks (2) and the position marks (4).

11. The mark field (4) according to one or more of claims 1 to 10, wherein spacings between adjacent location marks (2) are smaller than the width and/or height or the diameter of the location marks

(2), with a ratio between the spacing and the width and/or height or the diameter of the location marks (2) smaller than 1.

12. The mark field (4) according to one or more of claims 1 to 10, wherein spacings between adjacent location marks (2) are smaller than the width and/or height or the diameter of the location marks (2), with a ratio between the spacing and the width and/or height or the diameter of the location marks (2) smaller than 0.5.

13. The mark field (4) according to one or more of claims 1 to 10, wherein spacings between adjacent location marks (2) are smaller than the width and/or height or the diameter of the location marks (2), with a ratio between the spacing and the width and/or height or the diameter of the location marks (2) smaller than 0.1.

14. The mark field (4) according to one or more of claims 1 to 13, wherein each mark (1) of the mark field (4) is different, and wherein the marks (1) comprising the location marks (2) and the position marks (4) has a different encoding.

15. The mark field (4) according to claim 14, wherein the encoding is a position encoding.

16. The mark field (4) according to one or more of claims 1 to 15, wherein encoding of the location mark (2) has one or more of the following characteristics:
- a QR code,
- a barcode,
- a geometric, particularly a three-dimensional figure,
- a character sequence and/or a number sequence, and
- an image.

17. The mark field (4) according to claim 16, wherein the character sequence is a letter sequence.

18. The mark field (4) according to claim 16, wherein the number sequence is a binary code.

19. A device for determining X-Y positions of structural features (11c) of structures (11) arranged on a substrate (7), the device comprising:
a substrate holder (8); and
a plurality of optical systems (13, 13'),
wherein the device is configured to determine the X-Y positions relative to a mark field (4) affixed to the substrate holder (8) and fixed with respect to the substrate (7), the mark field (4) comprising:
- at least two location marks (2) with information for the location of the respective location mark (2) in the mark field (4), and
- at least one position mark (3), which is or can be assigned to one of the at least two location marks (2),

wherein the location mark (2) is an encoded mark and the position mark (3) is associated with the location mark (2),

wherein the mark field (4) is located on a substrate holder (8) on which the substrate (7) is fixed, and

wherein at least one of the two location marks (2) and the at least one position mark (3) are optically measurable, the optical systems (13. 13') configured to simultaneously optically detect both the at least one of the two location marks (2) and the at least one position mark (3) within a predefined viewing area.

20. A method for determining X-Y positions of structural features (11c) of structures (11) arranged on a substrate (7), wherein the X-

Y positions are determined relatively to a mark field (4) fixed with respect to the substrate (7), the method comprising:

- providing at least two location marks (2) with information for the location of the respective location mark (2) in the mark field (4),
- providing at least one position mark (3), which is or can be assigned to one of the at least two location marks (2), wherein the location mark (2) is an encoded mark and, the position mark (3) associated with the location mark (2),
- locating the mark field (4) on a substrate holder (8) on which the substrate (7) is fixed by simultaneously optically detecting at least one of the two location marks (2) and the at least one position mark (3) within a predefined viewing area of an optical system (13).