METHOD OF DETERMINING A CENTRED POSITION OF A SEMICONDUCTOR SUBSTRATE IN AN ANNEALING FURNACE, DEVICE FOR THE HEAT TREATMENT OF SEMICONDUCTOR SUBSTRATES AND METHOD FOR CALIBRATING SUCH A DEVICE

GENERAL TECHNICAL FIELD

The present invention relates to the heat treatment of semiconductor substrates.

More precisely, it relates to the positioning of semiconductor substrates on a retention support in a furnace with a view to carrying out a heat treatment.

TECHNICAL PROBLEM

It may be necessary to apply a heat treatment to a semiconductor substrate, for example to increase its strength or to reduce structural defects induced by a production process.

Referring to Figures 1a and 1b, a circular semiconductor substrate 10 is placed, in certain furnaces, horizontally on an annular retention support 20 shown in a bottom view in Figure 1a and in a sectional side view in Figure 1b.

During a heat treatment, heat from the substrate 1 is dissipated in the annular support 20 via the contact zone C, shown cross-hatched in Figure 1a.

If the substrate is off-centre relative to the annular support, this heat dissipation is asymmetrical, the resulting thermal gradients causing structural defects in the substrate, for example defects of the slip line type.

It is therefore preferable for the substrate to be centred as closely as possible on the annular support before the heat treatment is started.

PRIOR ART

There are methods for qualitatively determining whether the substrate is centred relative to the support.

For example, the substrate may be rotated on a support rotating relative to its centre and the centring may be optically evaluated from the shape described by the rotating substrate.

This method is used to determine whether the substrate is incorrectly

placed, but provides no quantitative indication about the shift required to position the substrate at the centre of the support. The substrate must therefore be moved by trial and error in order to obtain the desired centred position.

This method is therefore costly in terms of time and is not very precise.

However, there is a method for quantitatively evaluating the offset of the substrate relative to the support.

This method includes a step of implanting species (for example, boron or phosphorus) capable of migrating at high temperature at a defined position on the surface of the substrate.

Next, a heat treatment is applied to the substrate and then the migration of the species is evaluated by an electrical resistance measurement.

The migration of the species provides quantitative information about the temperature symmetry during the heat treatment, said information being indicative of the centring of the substrate on the support. It is then possible to centre the substrate on the basis of this quantitative information.

However, the implantation of species into the substrate is an expensive step to implement and requires further specific equipment.

SUMMARY OF THE INVENTION

The object of the invention is to alleviate this drawback and to provide a simple method for centring a substrate on an annular support.

For this purpose, the invention provides, according to a first aspect, a method of determining a centred position of a semiconductor substrate placed in an annealing furnace, in a starting position, on a retention support in the furnace, the method comprising the following steps:

- heat treatment of the substrate in its starting position, the treatment resulting in the formation of an oxide layer on the substrate;
- measurement of the thickness of the substrate at several points on the oxidized surface of the substrate, the position of the measurement points on the substrate being known; and
- determination, on the basis of the measurement step and the starting position, of a centred position of the substrate on the support.

The invention provides, according to a second aspect, a method of calibrating a device for the heat treatment of semiconductor substrates, the

device comprising means for positioning semiconductor substrates on a retention support in a furnace, the positioning means comprising a memory unit, intended to store positioning parameters, and an actuator capable of positioning a substrate on the support according to positioning parameters stored in the memory unit, the method comprising the following steps:

- positioning by the actuator of a test substrate on the support in a starting position according to predetermined starting parameters;
- application of the steps of the method of determining a centred position according to the first aspect of the invention to the test substrate;
- determination of centring parameters corresponding to the centred position of the test substrate; and
- storage of the centring parameters in the memory unit.

The calibrating method according to the second aspect of the invention is advantageously iterative, all the steps of the method being repeated according to a given number of iterations, the centring parameters determined at each iteration being taken as starting parameters for the next iteration.

According to a third aspect, the invention provides a device for the heat treatment of semiconductor substrates, comprising:

- a furnace with a retention support;
- a measurement unit for determining a thickness of the substrate at several measurement points; and
- positioning means comprising:

a memory unit for storing positioning parameters corresponding to positions of a substrate on the support,

an actuator for positioning a substrate on the support according to positioning parameters stored in the memory unit and

a processing unit for determining, as a function of a starting position and measurements by the measurement unit, a centred position and for determining centring parameters from said centred position,

the memory unit being furthermore designed to store centring parameters so that the actuator is able to position semiconductor substrates on the support in the centred position.

The invention has many advantages.

The invention provides a simple way of determining a centred position of a substrate on an annular support on the basis of a starting position and a heat

treatment.

The invention also makes it possible to calibrate a device for the heat treatment of substrates, so as to reduce the defects induced by an offset of the substrates to be treated on the annular support.

PRESENTATION OF THE FIGURES

Other features, objects and advantages of the invention will emerge from the following description, which is purely illustrative and non-limiting and must be read in conjunction with the appended drawings in which:

- Figures 1a and 1b, already commented upon, show schematically a substrate on an annular support in a bottom view and in a sectional side view respectively;
- Figures 2a and 2b show schematically a substrate on an annular support after heat treatment according to one possible way of implementing the methods according to the first and second aspects of the invention, in a bottom view and in a sectional side view respectively;
- Figure 2c shows, schematically in a top view, measurement points on the oxide layer covering a substrate according to one possible way of implementing the first and second aspects of the invention;
- Figure 3 shows, in the form of a block diagram, a method of determining a centred position of a semiconductor substrate according to one possible way of implementing the first aspect of the invention;
- Figure 4 shows, in the form of a block diagram, a method of calibrating a device for the heat treatment of semiconductor substrates, in accordance with one possible way of implementing the second aspect of the invention; and
- Figure 5 shows, in the form of a block diagram, a device for the heat treatment of semiconductor substrates according to one possible embodiment of the third aspect of the invention.

DETAILED DESCRIPTION

Referring to Figures 2a and 2b, the purpose of the method according to the first aspect of the invention is to determine a centred position of a semiconductor substrate 10 placed on a retention support 20 in an annealing furnace.

Initially, the substrate is placed on the support 20, assumed to be annular, in a starting position P1 *a priori* off-centre relative to the centre of the support 20.

In Figure 2a, the substrate 10 has a disc shape and its position P1 is identified by its centre. However, the invention is not limited to a disc-shaped substrate, and extends more generally to any plane substrate shape.

Referring to Figure 3, the method according to the first aspect of the invention comprises a first step S1 for heat treatment of the substrate 10 in its starting position P1.

This treatment S1 results in the formation of an oxide layer 11 on the substrate 10.

In the context of the invention, the term "oxide layer" is understood to mean any layer that can be grown during a heat treatment on the semiconductor substrate, the thickness of said layer depending on the temperature.

This definition is not exclusively limited to oxides, rather it also includes nitrides.

A distinction is made below between a lower surface of the substrate 10, in contact with the support 20, and an upper surface on the opposite side from the lower surface. Preferably, the oxide layer 11 is located on the upper surface of the substrate 10.

As shown in Figure 2b, the oxide layer 11 has a thickness that varies, most particularly at the point corresponding to the contact zone C between the substrate 10 and the support 20. The heat dissipation in the support 20 slows down the growth of the oxide layer 11. The variations in thickness of the layer 11 thus constitute an impression of the support 20 in contact with the lower surface of the substrate 10. This impression is shown cross-hatched in Figure 2c (in a top view).

The method according to the first aspect of the invention further includes a step S2 of measuring the thickness of the substrate at several points on the oxidized surface of the substrate, i.e. the layer 11.

The position of each measurement point relative to the support 20 is known and predetermined. For example, a dotted circle concentric with the support 20 is shown, constituting one possible distribution of the points for measuring the thickness of the layer according to the first aspect of the invention.

It may be seen in Figure 2c that this circle is partly located in the cross-

hatched zone in which the thickness of the oxide layer 11 is smaller. Thus, the measured thickness will be smaller in this zone, indicating that the substrate is off-centre relative to the support.

Of course, the cross-hatching merely shows a schematic illustration of the impression of the annular support on the oxide layer 11. In fact, this impression is not very pronounced, but represents more of a degradation in thickness uniformity as may be readily imagined from Figure 2b.

The thickness measurement may be carried out by ellipsometry or by any other suitable means known to those skilled in the art.

The dotted circle in Figure 2c is given by way of non-limiting example. Other configurations of measurement point positions are envisaged in the context of the invention. In particular, the invention covers the measurement point positions already explained by the Applicant in patent application WO 2006/051243.

The method according to the first aspect of the invention also includes a step S3, on the basis of the measurement step S2 and the starting position P1, of determining a centred position P2 of the substrate 10 on the support 20.

Advantageously, the determination of the position P2 comprises predetermining a direction and sense of the offset from P1 and calculating the amount of offset in the predetermined direction and sense.

To give a non-limiting example, the direction and sense of the offset from P1 may be determined by the vector connecting the point where the measured thickness is the greatest to the point where it is the smallest.

Advantageously, the amount of offset is determined as a function of the thickness measured at several measurement points, preferably all of the measurement points, for example by comparing the results of the measurement with a predetermined model.

The method according to the first aspect of the invention thus makes it possible to quantitatively determine the shift to be made with respect to the starting position P1 in order to obtain a centred position P2 relative to the support 20.

Moreover, the steps of this method may be implemented for calibrating a device used for the heat treatment of semiconductor substrates.

For this purpose, the invention provides, according to a second aspect, a calibrating method as shown in Figure 4. The device intended to be calibrated is

a device according to the third aspect of the invention, shown in the form of a block diagram in Figure 5.

This device, with the reference 100, comprises means 40 for positioning semiconductor substrates 10 on a retention support 20 in a furnace 30. The positioning means comprise a memory 42, designed to store positioning parameters PP, and an actuator 41 capable of positioning a substrate 10 on the support 20 according to positioning parameters PP stored in the memory unit 42.

The method according to the second aspect of the invention includes a step S0 of positioning a test substrate T on the support 20 in a starting position P1 according to predetermined starting parameters PP1.

This step is carried out by the actuator 41 of the device according to the third aspect of the invention. The parameters PP1 are prestored in the memory unit 42. These may be default parameters, parameters set by a user, or, as will be seen later in the advantageous case of an iterative method, parameters determined during a preceding iteration.

The method according to the second aspect of the invention further includes determining a centred position P2 by applying the steps of the method according to the first aspect of the invention to the test substrate T, and also a step S4 of determining centring parameters PP2 corresponding to the centred position P2.

The measurements are carried out by a measurement unit 60 of the device according to the third aspect of the invention. The unit 60 transmits the measurements to a processing unit 50 of the device, configured to determine, as a function of the starting position P1 of the test substrate T and the transmitted measurements, the centred position P2 and deduce therefrom the centring parameters PP2.

The method according to the second aspect of the invention further includes a step of storing these parameters PP2 in the memory unit 42. The test substrate T is then taken off the support 20 and removed from the annealing furnace 30.

The substrates to be treated will then be positioned in the position P2 in the furnace, which is thus calibrated for a heat treatment in which the temperature asymmetries due to an off-centre position of the substrates on the support 20 are reduced.

The position P2 thus obtained according to the invention is centred to one

tenth of a millimetre. For greater precision in this position, the method according to the second aspect of the invention may be applied a second time with a new test substrate, taking as starting position the determined centring position.

In general, the method according to the second aspect of the invention is advantageously iterative, the starting parameters for one iteration being the centring parameters determined in the preceding iteration. A new test substrate is used at each iteration.

Two iterations of the method according to the second aspect of the invention are sufficient for obtaining a precision of the order of one hundredth of a millimetre.

CLAIMS

1. Method of determining a centred position of a semiconductor substrate (10) placed in an annealing furnace (30), in a starting position (P1), on a retention support (20) in the furnace, characterized in that it comprises the following steps:

- heat treatment (S1) of the substrate (10) in its starting position (P1), the treatment (S1) resulting in the formation of an oxide layer (11) on the substrate (10);
- measurement (S2) of the thickness of the substrate at several points on the oxidized surface of the substrate, the position of the measurement points on the substrate being known; and
- determination (S3), on the basis of the measurement step (S2) and the starting position (P1), of a centred position (P2) of the substrate (10) on the support (20).

2. Method of calibrating a device (100) for the heat treatment of semiconductor substrates, the device (100) comprising means (40) for positioning semiconductor substrates (10) on a retention support (20) in a furnace (30), the positioning means (40) comprising a memory unit (42), intended to store positioning parameters (PP), and an actuator (41) capable of positioning a substrate (10) on the support (20) according to positioning parameters (PP) stored in the memory unit (42), the method being characterized in that it comprises the following steps:

- positioning (S0) by the actuator (41) of a test substrate (T) on the support (20) in a starting position (P1) according to predetermined starting parameters (PP1);
- application of the steps of the method of determining a centred position (P2) according to Claim 1 to the test substrate (T);
- determination (S4) of centring parameters (PP2) corresponding to the centred position (P2) of the test substrate (T); and
- storage (S5) of the centring parameters (PP2) in the memory unit (42).

3. Calibrating method according to the preceding claim, in which all the steps of the method are repeated according to a given number of iterations, the centring parameters (PP2) determined at each iteration being taken as starting parameters (PP1) for the next iteration.

4. Device (100) for the heat treatment of semiconductor substrates (10), characterized in that it comprises:

- a furnace (30) with a retention support (20);
- a measurement unit (60) for determining a thickness of the substrate (10) at several measurement points; and
- positioning means (40) comprising:

a memory unit (42) for storing positioning parameters (PP) corresponding to positions of a substrate on the support (20),

an actuator (41) for positioning a substrate (10) on the support (20) according to positioning parameters (PP) stored in the memory unit (42) and

a processing unit (50) for determining, as a function of a starting position (P1) and measurements by the measurement unit (60), a centred position (P2) and for determining centring parameters (PP2) from said centred position (P2),

the memory unit (42) being furthermore designed to store centring parameters (PP2) so that the actuator (41) is able to position semiconductor substrates (10) on the support (20) in the centred position (P2).