Epitaxially coated Semiconductor Wafer and Device and Method for Producing an Epitaxially coated Semiconductor Wafer

The invention relates to a semiconductor wafer having a front side coated by chemical vapor deposition (CVD) and to a method for producing this semiconductor wafer. The invention also relates to a device for supporting a semiconductor wafer during the deposition of a layer on a front side of the semiconductor wafer by chemical vapor deposition (CVD).

During chemical vapor deposition, in particular the deposition of an epitaxial layer on a polished semiconductor wafer, inter alia two phenomena may occur which are known by the terms "autodoping" and "halo".

In "autodoping", dopants pass from the backside of the semiconductor wafer via the gas phase into the deposition gas, which is fed over the front side of the semiconductor wafer. They are then incorporated into the epitaxial layer, predominantly in the edge region of the front side of the semiconductor wafer, and therefore cause more or less pronounced undesired radial variation in the resistivity of the epitaxial layer.

"Halo" refers to a scattered light effect which is caused by light-scattering structures on the backside of the semiconductor wafer and is observable by shining a collimated light beam onto the backside of the semiconductor wafer. The structures mark transitions, on the surface of the backside of the semiconductor wafer, at which regions with a native oxide layer adjoin regions where such an oxide layer is not or no longer present. These transitions occur when removal of the native oxide layer during the pretreatment in a hydrogen atmosphere ("pre-bake") before the actual

epitaxial deposition was incomplete. One possibility for quantifying this effect consists in a scattered-light measurement of the haze (turbidity, opacity), for example with an SP1 light scattering meter from KLA Tencor, in the so-called DNN ("DarkField Narrow Normal") or DWN ("DarkField Wide Normal) channel.

In order to avoid problems with "autodoping", US 6129047 proposes to provide slits in the bottom of the susceptor's recess ("pocket") holding the semiconductor wafer, the slits being arranged on the outer edge of the bottom. Dopants diffusing out from the backside of the semiconductor wafer can be removed from the reactor, without previously reaching the front side of the semiconductor wafer, by a flushing gas which is fed through slits in the susceptor onto the wafer backside.

According to US 6596095 B2, there are small bores in the entire bottom of the susceptor for the same purpose. Here again, the dopant diffusing out from the backside of the semiconductor wafer is transported away by feeding a flushing gas past. These measures are also effective against "Halo" formation because they facilitate removal of the native oxide layer, since gaseous reaction products which are created by dissolving the native oxide are likewise transported away through the holes in the bottom and the flushing gas flowing past.

DE 10328842 discloses a susceptor, which has a gas-permeable structure with a porosity of at least 15% and a density of from 0.5 to 1.5 g/cm^3. By using such a porous susceptor, the gaseous reaction products which are formed during the pretreatment by dissolving the native oxide layer and the dopants diffusing from the semiconductor wafer to be coated can escape through the pores of the susceptor to the backside of the susceptor, and be taken up by a flushing gas flow and removed from the reactor. Using the described susceptor

also avoids undesired nanotopography effects on the backside of the semiconductor wafer, which occur in the case of susceptors with holes. Holes in the susceptor affect the temperature field on the front side and backside of the semiconductor wafer to be coated, which leads to locally different deposition rates and finally to said nanotopography effects. The term nanotopography refers to height variations in the nanometer range, which are measured over a lateral extent of from 0.5 mm to 10 mm.

Another problem in the epitaxial coating of semiconductor wafers involves stresses in the epitaxially coated semiconductor wafers, which can lead to dislocations and slips.

Several methods for identifying slips in semiconductor wafers are known: on the one hand by visual inspection with collimated light, by means of devices for inspecting the surface of semiconductor wafers or with devices which are suitable for determining the nanotopography.

The most sensitive method in this context, however, is SIRD ("Scanning Infrared Depolarization") since not only slips but also photoelastic stresses can be measured by means of SIRD. The SIRD method for identifying stress fields, slips, sliplines, epitaxial defects, which is based on optical birefringence being introduced, is described for example in US 6825487 B2.

Thermally induced stresses in epitaxially coated semiconductor wafers can be avoided during the epitaxial coating of semiconductor wafers by reducing the temperatures during the pretreatment steps in a hydrogen atmosphere (bake) and with the addition of hydrogen chloride to the hydrogen atmosphere (HCl etch) and in the actual coating step.

Lower coating temperatures, however, lead to an increased occurrence of undesired crystal defects such as stacking faults or typical epitaxial defects which are known by the terms "hillocks", "mounds" or "pits". At very low temperatures, polycrystalline growth may even take place. Another disadvantage is an inferior edge roll-off of the epitaxial layer as well as a deterioration in the local planarity of the semiconductor wafer (geometry, SFQR). The growth rate is furthermore reduced with lower deposition temperatures, which makes the process less economical.

Reducing the pretreatment and deposition temperatures is therefore not acceptable owing to the associated disadvantages.

The prior art has not yet revealed any solution approaches relating to the reduction of stresses, dislocations and slips in epitaxially coated semiconductor wafers with high pretreatment and deposition temperatures, which are categorically necessary as explained above.

Embodiments of the invention seek to provide stress-free epitaxially coated semiconductor wafers having good edge roll-off values as well as good local planarity, while avoiding undesired crystal defects, backside halo, autodoping and nanotopography effects.

Embodiments of the invention relate to a device for supporting a semiconductor wafer during the deposition of a layer on a front side of the semiconductor wafer by chemical vapor deposition in an epitaxial reactor, containing a susceptor which has a gas-permeable structure and a ring, placed on the susceptor, which acts as a thermal buffer between the susceptor and the supported semiconductor wafer.

The susceptor is preferably one which has a porosity (pore volume/total volume) of at least 15% and a density of from 0.5 to 1.5 g/cm^3.

The necessary porosity and density of the susceptor may be obtained by suitable compression of fibers or particles during production of the susceptor.

The susceptor preferably consists of graphite or graphite fibers.

The susceptor is preferably coated with silicon carbide.

The device according to the invention comprises a ring which is placed on the susceptor, the ring preferably being selected in respect of its thickness and in respect of its material properties so that it acts as a thermal buffer between the susceptor and the supported semiconductor wafer.

This ring preferably has an inner diameter which is less than the diameter of the semiconductor wafer to be received.

The outer diameter of the ring is preferably greater than the diameter of the semiconductor wafer to be received, and preferably corresponds to the diameter of the susceptor.

An outer diameter of the ring which is a few mm greater than the diameter of the susceptor is particularly preferred.

The ring is preferably at least 0.5 mm thick, particularly preferably 0.5-1.5 mm thick and more particularly preferably 1 mm thick.

The ring furthermore preferably has a likewise annular recess for receiving semiconductor wafers.

The annular recess preferably has a depth of 0.3-0.7 mm, particularly preferably 0.5 mm and a width of 3-15 mm, particularly preferably 6 mm.

The ring is preferably a ring of silicon carbide.

The use of a graphite ring, which is coated with silicon carbide, is also preferred.

The ring preferably consists of a material having a thermal conductivity at 1000°C of 5-100 W/mK, particularly preferably 5-50 W/mK and more particularly preferably 10-30 W/mK.

The device according to the invention is preferably used in single-wafer reactors.

Use in single-wafer reactors from ASM and Applied Materials [AMAT Centura Epi} is particularly preferred.

The device according to the invention is preferably configured to receive semiconductor wafers having a diameter of 150mm, 200 mm, 300 mm and 450 mm.

According to the first aspect of the invention, there is provided a method for producing epitaxially coated semiconductor wafers, in which a multiplicity of semiconductor wafers polished at least on their front sides are prepared and successively coated individually by applying an epitaxial layer onto their polished front sides by chemical vapor deposition at temperatures of 800-1200°C in an epitaxial reactor, by respectively supporting one of the prepared semiconductor wafers on a device for supporting a

semiconductor wafer so that the semiconductor wafer rests on the ring, its backside faces a bottom of the susceptor having a gas-permeable structure but does not touch the susceptor, so that gaseous substances are delivered from a region over the backside of the semiconductor wafer by gas diffusion through the susceptor into a region over the backside of the susceptor, and furthermore the semiconductor wafer comes in contact with the ring only in the edge region of its backside, with no stresses measurable by means of photoelastic stress measurement ("SIRD") occurring in the semiconductor wafer.

In the method according to the invention, a multiplicity of semiconductor wafers polished at least on their front sides are initially prepared.

To this end a single crystal produced according to the prior art, preferably by crucible pulling according to Czochralski, is sliced into a multiplicity of semiconductor wafers by means of known slicing methods, preferably using wire saws with free abrasive ("slurry") or bound abrasive (diamond wire).

Mechanical processing steps are furthermore carried but, for instance sequential single-sided grinding methods, simultaneous double-sided grinding methods (DDG) or lapping. The edge of the semiconductor wafer, including any existing mechanical markings such as a notch or a flat, are generally also processed ("edge-notch grinding").

Chemical treatment steps are furthermore provided, which comprise cleaning and etching steps.

After the grinding, cleaning and etching steps, according to the prior art the surface of the semiconductor wafers is preferably smoothed by stock polishing. This is preferably done by double-sided

polishing (DSP), to which end the semiconductor wafers are placed loosely in a thin toothed disk and polished simultaneously on the front side and backside while "floating freely" between an upper polishing plate and a lower polishing plate, covered with a polishing cloth.

The front sides of the prepared semiconductor wafers are furthermore preferably polished free from streaks, for example by a soft polishing cloth with the aid of an alkaline polishing sol. In the literature, this step is often referred to as CMP polishing ("chemical-mechanical polishing").

After the polishing, the semiconductor wafers are preferably subjected to hydrophilic cleaning and drying according to the prior art.

Epitaxial layers are subsequently deposited on the polished front sides of the prepared semiconductor wafers in a single-wafer reactor.

The semiconductor wafer in this case rests not directly on the susceptor, but on a ring which is in turn placed on the susceptor, so that the backside of the semiconductor wafer faces a bottom of the susceptor.

The bottom of the susceptor has a gas-permeable structure.

The susceptor preferably has a porosity (pore volume/total volume) of at least 15% and a density of from 0.5 to 1.5 g/cm^3.

The ring rests on this susceptor. The ring is thus not connected to the susceptor.

The ring is preferably selected in respect of its thickness and in respect of its material properties so

that it acts as a thermal buffer between the susceptor and the supported semiconductor wafer.

The ring is preferably at least 0.5 mm thick, particularly preferably 0.5-1.5 mm thick and more particularly preferably 1 mm thick.

The ring furthermore preferably has a likewise annular recess for receiving semiconductor wafers.

The annular recess preferably has a depth of 0.3-0.7 mm, particularly preferably 0.5 mm and a width of 3-15 mm, particularly preferably 6 mm.

The ring is preferably a ring of silicon carbide.

The use of a graphite ring, which is coated with silicon carbide, is also preferred.

The ring preferably consists of a material having a thermal conductivity at 1000°C of 5-100 W/mK, particularly preferably 5-50 W/mK and more particularly preferably 10-30 W/mK.

The epitaxial reactor is preferably a single-wafer reactor, particularly preferably a single-wafer reactor from ASM or Applied Materials (AMAT Centura Epi).

The prepared semiconductor wafers preferably have a diameter of 150mm, 200 mm, 300 mm and 450 mm.

The inventors have discovered that the effects of susceptors already described in the prior art having gas-permeable structures (felt, pores, holes, slits, bores) on the properties of the backside of the semiconductor wafer in respect of halo and nanotopography are also maintained in the method according to the invention, i.e. for the case in which

the semiconductor wafer rests not directly on the susceptor but on a ring.

This is already observable during the pretreatment of the semiconductor wafer when the semiconductor wafer to be epitaxially coated is preheated and exposed to a flushing gas, usually a hydrogen atmosphere, in order to remove the native oxide layer.

The gaseous reaction products formed when dissolving the oxide layer, as well as the dopant diffusing from the semiconductor wafer, escape by gas diffusion through the gas-permeable structure of the susceptor, i.e. through the pores or openings of the susceptor, through to the backside of the susceptor where they are taken up by the flow of flushing gas and removed from the reactor stream.

After the oxide layer has been removed, an etchant, preferably hydrogen chloride, is added to the flushing gas in order to smooth the surface of the front side of the semiconductor wafer before depositing the epitaxial layer.

In order to deposit the epitaxial layer, the semiconductor wafer to be epitaxially coated is brought to the deposition temperature and the front side of the semiconductor wafer is brought in contact with a deposition gas, while the backside of the substrate wafer preferably continues to be exposed to the effect of the flushing gas.

The deposition gas contains compounds which, after they are chemically cleaved, provide substances that form the layer. These substances preferably include silicon, germanium and the dopants such as boron.

A deposition gas made up of trichlorosilane, hydrogen and diborane is particularly preferred.

After the epitaxial layer has been deposited, the epitaxially coated semiconductor wafer is cooled, for example in a flow of hydrogen which is fed through the reactor.

The effect of the ring resting on the susceptor is that the semiconductor wafer has no contact with the susceptor and therefore comprises no stress points in its surface. The semiconductor wafer is therefore stress-free, i.e. has no mechanical stresses, in its surface.

A ring made of silicon carbide furthermore serves to create a kind of insulation or thermal buffer between the semiconductor wafer and the susceptor. The effect of this is that no thermally induced stresses, which could lead to dislocations and slips, occur even on the bearing points at the edge.

For example, the SIRD Metrology System from PVA TePla or the SIRD-300 device from JenaWave is suitable for determination of the stresses. The sensitivity of the TePla SIRD device is 6 kPa. A stress-free semiconductor wafer in the scope of this invention is therefore intended to mean a semiconductor wafer which has no stresses of 6 kPa or more. Both the front side and backside and also the edge region of the semiconductor wafer can be studied with these SIRD measuring instruments. There is no edge exclusion, as for example in the case of geometry measuring instruments. Unless otherwise indicated, data regarding stresses in semiconductor wafers studied by means of SIRD therefore relate respectively to the front side and backside and to the edge region (without edge exclusion) of the semiconductor wafer.

Silicon carbide is also particularly suitable as a ring material because it is hard, solid but not brittle

(like for instance quartz), relatively inexpensive and furthermore readily processable. Silicon carbide is opaque (turbid), and therefore does not lead to light guide effects.

The single-wafer reactors used are heated from above and below by means of IR lamps.

The effect of this, when using a conventional susceptor, is that the semiconductor wafer is at a higher temperature than the susceptor during the pretreatment and coating steps. Thermally induced stresses therefore occur at the points of contact with the susceptor, which in the worst case can lead to dislocations and slip of the semiconductor wafer.

In the case of a susceptor having a ring, especially a ring of silicon carbide, however, the temperature of the ring is higher than that of the susceptor and has a temperature value close to the temperature of the semiconductor wafer. The thermal stresses occurring in the prior art can therefore be avoided.

The effect also occurs when the temperature of the semiconductor wafer is lower than the temperature of the susceptor, as is the case when cooling the semiconductor wafer after the deposition process. Here again, the ring acts as a kind of thermal buffer.

Another advantage of the method according to the invention and the device according to the invention is that the ring can be processed very accurately, specifically both in its dimensioning and with respect to its roughness. The adaptation of the device according to the invention to the semiconductor wafer can therefore be improved, which also makes it possible to avoid mechanical stress fields at the bearing points of the semiconductor wafer.

According to an embodiment of the invention, the ring rests directly on the susceptor. The alternative, i.e. to hold the ring a few millimeters above the susceptor surface by means of spacers, is however not preferred because, although this would have the advantage that gases diffusing out from semiconductor wafers doped heavily on the backside could escape laterally below the ring and "autodoping" effects could therefore be reduced, on the other hand the thermal equilibration effect would nevertheless be reduced owing to the increased distance of the ring (and therefore the semiconductor wafer) from the susceptor, and the susceptibility in terms of thermally induced stresses and slips would be increased. Deposition gas could furthermore enter between the ring and the susceptor so that the wafer backside would also be coated, which is undesirable.

In the method according to the invention, conversely, the ring rests firmly so that any backside depositions are avoided since the deposition gas cannot enter between the susceptor and the semiconductor wafer, and cannot therefore reach the backside of the semiconductor wafer.

The semiconductor wafer to be epitaxially coated is preferably a wafer of monocrystalline silicon, onto which an epitaxial silicon layer is applied.

The semiconductor wafer to be epitaxially coated is preferably polished at least on its front side.

Preferably, the semiconductor wafer to be epitaxially coated is etched and polished on its backside.

Preferably, the semiconductor wafer to be epitaxially coated has a diameter of 150 mm, 200 mm, 300 mm or 450 mm.

Another advantage of the method according to the invention is that it allows the process window to be widened in respect of the deposition temperatures:

Conventionally, p- silicon wafers (silicon wafers with a low doping level) are more sensitive to stresses than p+ silicon wafers with a higher doping level.

The temperature for depositing an epitaxial layer onto p+ silicon wafers can therefore be selected to be higher compared with p- silicon wafers.

Typical deposition temperatures according to the prior art (in single-wafer reactors) are as follows:

p-/p+ (weakly doped epitaxial layer on heavily doped silicon wafers): 1120-1150°C.

p-/p- (weakly doped epitaxial layer on weakly doped silicon wafers): 1080-1120°C.

In the method according to the invention, conversely, said temperature ranges can be increased preferably by 20-30°C (i.e: up to 1180°C for p-/p+ and up to 1150°C for p-/p-): an epitaxially coated silicon wafer is obtained which is stress-free according to SIRD, with reduced defects and an improved geometry compared with the prior art.

The deposition temperatures in the scope of this invention are therefore preferably selected as follows:

On silicon wafers with a high doping level (p+), the epitaxial deposition is carried out at a temperature of 1140-1180°C.

On silicon wafers with a low doping level (p-), the deposition is carried out at a temperature of 1100-1150°C.

Another advantage of the elevated deposition temperatures is that the edge roll-off of the polished semiconductor wafer can thereby be improved, since the layer thickness profile of the epitaxial layer at the edge of the semiconductor wafer increases with elevated deposition temperatures and the edge roll-off can thereby be compensated for.

According to the second aspect of the invention, there is provided a semiconductor wafer which comprises a front side and a backside, which is provided on its front side with an epitaxial layer that is furthermore free from stresses according to photoelastic stress measurement ("SIRD") and which furthermore has a nanotopography on its backside, expressed as PV height variation (= peak to valley) of greater than or equal to 2 nm and less than or equal to 5 nm based on square measurement windows with an area of 2 mm x 2 mm and a backside "halo" expressed as haze of greater than or equal to 0,1 ppm and less than or equal to 5 ppm.

The semiconductor wafer according to the invention is free from stresses according to characterization by SIRD.

It furthermore has good nanotopography and haze values on its backside.

The semiconductor wafer according to the invention has on the one hand no stress points in its surface and is therefore stress-free, i.e. free from any mechanical or thermally induced stresses, in its surface.

By using a ring of silicon carbide in the method according to the invention, which - as already described above - can be processed very well (particularly in respect of its roughness), the

mechanical stress fields at the edge of the semiconductor wafer (in the prior art at the bearing points of the semiconductor wafer on the susceptor) can moreover be avoided.

The semiconductor wafer according to the invention is therefore preferably free from any stresses according to characterization by means of photoelastic stress measurement (SIRD), both on its front side and on its backside as well as in the edge region.

The crystal defects, referred to as LPD ("light point defects") owing to the measurement method employed, are for example epi stacking faults, hillocks or pits, and in general structural epitaxy defects which can be detected by means of light scattering as LLS ("localized light scatterers") by surface inspection instruments, for example KLA Tencor Surfscan SP1.

Studies on semiconductor wafers according to the invention showed the following results, respectively measured in the dark field, oblique mode (DWO, DNO) (oblique incidence angle of the laser in the SP1):

Defect size class:	50% of wafers	97.7% of wafers
≥ 50 nm	≤ 2 defects	≤ 8 defects
≥ 90 nm	0 defects	≤ 4 defects
≥ 120 nm	0 defects	≤ 3 defects
≥ 200 nm	0 defects	≤ 2 defects

For a yield of >= 97.7% (economically acceptable >= 90%) this means: 8 LLS defects >= 50 nm; 4 LLS defects >= 90 nm; 3 LLS defects >= 120 nm; 2 LLS defects >= 200 nm.

With respect to the local planarity of the semiconductor wafer according to the invention, the following results are found:

The semiconductor wafer preferably has a maximum local planarity value $SFQR_{max}$ of greater than or equal to 0.025 µm and less than or equal to 0.04 µm.

The maximum local planarity value $SFQR_{max}$ of from 0.025 µm to 0.04 µm is preferably based on at least 99% of the subregions of a two-dimensional grid of measurement windows with a size of 26×8 mm^2 on the front side of the coated semiconductor wafer and an edge exclusion of 2 mm.

Comparison with semiconductor wafers epitaxially coated on a standard susceptor (according to the prior art, i.e. without a ring support) shows a significant improvement by the semiconductor wafer according to the invention. Comparative tests under otherwise equal process conditions, but by using a standard susceptor instead of the device according to the invention, gave a maximum local planarity value $SFQR_{max}$ of 0.045-0.08 µm for the epitaxially coated semiconductor wafers.

The semiconductor wafer according to the invention furthermore preferably has an R30-1mm parameter of from -10 nm to +10 nm which corresponds to a deviation, measured at a distance of 1 mm from the edge of the silicon wafer, of an average cross section determined by thickness measurement from a reference line determined by regression. This is an edge roll-off parameter.

The epitaxially coated semiconductor wafer preferably has an R30-1mm parameter of from -5 nm to +5 nm.

The negative R30-1mm values correspond to a roll-up, i.e. in this case the edge roll-off of the semiconductor wafer was overcompensated for by the epitaxial coating.

A method for measuring the edge roll-offs of silicon wafers is described in Jpn. J. Appl. Phys. Vol. 38 (1999) pp 38-39. Edge roll-off parameters related to the thickness of a silicon wafer may for example be determined by means of the NanoPro NP1 topography measuring system from KLA Tencor, by initially calculating 360 radial cross sections with a spacing of 1° of the entire image (topography, "wafer map") of a silicon wafer, starting at the center of the wafer. The cross sections are conventionally divided into 4 sectors S2 to S5 (respectively 90° sectors) and all 90 radial cross sections are averaged for each sector. For a region with a distance of from R-5 mm to R-35 mm from the edge of the wafer, a 3rd order fitted reference line ("best fit") is calculated. Finally, the fourfold symmetry of the edge roll-off is averaged out (by averaging over all the radial thickness cross sections) and for example an R30-1mm parameter is obtained by determining the deviation between the averaged radial cross section and the reference line determined by regression at a distance of R-1 mm from the edge of the wafer.

The deviations between the average radial cross sections per sector (individual tracks) and the reference line may also be considered as an alternative, so as to obtain a roll-off value for each sector. In the scope of the present invention, average roll-off values were considered.

The semiconductor wafer according to the invention furthermore preferably has a resistance uniformity in the epitaxial layer of greater than or equal to ±2% and less than or equal to ±5%.

A µPCD lifetime is preferably 2500 - 3000 µs. This is the minority carrier or recombination lifetime (µPCD = "micro photo conductive decay"), which is determined by means of light technology excitation and subsequent

measurement of the decay curve.

The semiconductor wafer is preferably a semiconductor wafer polished on the front side and provided with an epitaxial layer on the polished front side.

Preferably, the semiconductor wafer is etched and polished on its backside.

Preferably, the semiconductor wafer has a diameter of 150 mm, 200 mm, 300 mm or 450 mm.

The epitaxially coated semiconductor wafer is preferably a wafer of monocrystalline silicon, onto which an epitaxial silicon layer is applied.

Figures

The invention will be illustrated below with the aid of figures.

Fig. 1 shows a device according to the invention.

Fig. 2 shows the result of an SIRD measurement (prior art).

Fig. 3 shows the result of an SIRD measurement on a semiconductor wafer according to the invention.

The meaning of the bearing points visible at the edge in SIRD measurements is explained by **Fig. 4.**

Fig. 1 schematically shows the structure of the device according to the invention. The ring 2 is placed on the susceptor 1. The ring 2 and the susceptor 1 have their dimensions configured to receive the substrate 3. The ring 2 contains an recess 2a in the edge region to receive the substrate 3.

Fig. 2 shows the result of an SIRD measurement of a semiconductor wafer epitaxially coated according to the prior art. Here, local stress fields can be seen in the surface of the semiconductor wafer with stress differences of up to 600 kPa. Stress fields can also be seen at the edge, which correspond to its stress differences of 13-45 kPa.

The interference patterns show no thickness variance of the wafer. "Fringes" are created by interference of the ordinary and extraordinary light rays, which respectively have a different propagation velocity.

Fig. 3 shows the result of an SIRD measurement on a semiconductor wafer according to the invention. The semiconductor wafer is free from any stress fields, measurable by means of SIRD, both in the surface and at the edge.

Bearing points of the semiconductor wafer on the supporting device of the SIRD measuring instrument can be seen at the edge. They are therefore not attributable to the method according to the invention, i.e. they do not correspond to stress fields such as in the prior art, which may result from the bearing points of the semiconductor wafer on the susceptor. No stress fields are detectable by means of SIRD. The semiconductor wafer thus has no stress fields with stress differences greater than or equal to 6 kPa.

Lastly, **Fig. 4** shows the meaning of the bearing points visible in **Fig. 3**. Three bearing points can be seen, which are caused by the semiconductor wafer being supported on the supporting device of the SIRD instrument. Another point can furthermore be seen, which is attributable to a mechanical marking such as a notch or a flat, or to a laser marking.

These bearing points, and a mechanical marking which may be provided, can be seen in any SIRD measurement on a semiconductor wafer. They are, however, not critical stress fields which would be quantitatively detectable by means of SIRD.

Patent Claims

1. A method for producing epitaxially coated semiconductor wafers, in which a multiplicity of semiconductor wafers polished at least on their front sides are prepared and successively coated individually by applying an epitaxial layer onto their polished front sides by chemical vapor deposition at temperatures of 800-1200°C in an epitaxial reactor, by respectively supporting one of the prepared semiconductor wafers on a device for supporting a semiconductor wafer so that the semiconductor wafer rests on the ring, its backside faces a bottom of the susceptor having a gas-permeable structure but does not touch the susceptor, so that gaseous substances are delivered from a region over the backside of the semiconductor wafer by gas diffusion through the susceptor into a region over the backside of the susceptor, and furthermore the semiconductor wafer comes in contact with the ring only in the edge region of its backside, and furthermore no stresses measurable by means of photoelastic stress measurement ("SIRD") occur in the semiconductor wafer.

2. The method as claimed in claim 1, characterized in that the prepared semiconductor wafers are wafers of monocrystalline silicon.

3. The method as claimed in claim 1, characterized in that a deposition temperature of 1140-1180°C is selected for the epitaxial coating of p+ doped silicon wafers.

4. The method as claimed in claim 1, characterized in that a deposition temperature of 1100-1150°C is selected for the epitaxial coating of p- doped silicon wafers.

5. A semiconductor wafer comprising a front side and a backside, which is provided on its front side with an epitaxial layer that is furthermore free from stresses according to photoelastic stress measurement ("SIRD") and which furthermore has a nanotopography on its backside, expressed as PV height variation (= peak to valley) of greater than or equal to 2 nm and less than or equal to 5 nm based on square measurement windows with an area of 2 mm × 2 mm and a backside "halo" expressed as haze of greater than or equal to 0,1 ppm and less than or equal to 5 ppm.

6. The semiconductor wafer as claimed in claim 5, characterized by an edge roll-off parameter of from -10 nm to +10 nm which corresponds to a deviation, measured at a distance of 1 mm from the edge of the silicon wafer, of an average cross section determined by thickness measurement from a reference line determined by regression.

7. The semiconductor wafer as claimed in claim 5, characterized by a maximum local flatness value $SFQR_{max}$ of greater than or equal to 0.025 µm and less than or equal to 0.04 µm.

8. The semiconductor wafer as claimed in claim 5, which has a resistance uniformity in the epitaxial layer of greater than or equal to ±2% and less than or equal to ±5%.

9. The semiconductor wafer as claimed in claim 5, which has a recombination lifetime by µPCD of 2500 - 3000 µs.

10. The semiconductor wafer as claimed in claim 5, characterized in that it is a wafer of monocrystalline silicon, onto which an epitaxial silicon layer is applied, which has a diameter of 150 mm, 200 mm, 300 mm or 450 mm.

Abstract

Epitaxially coated Semiconductor Wafer and Device and Method for Producing an Epitaxially coated Semiconductor Wafer

The invention relates to a method for producing epitaxially coated semiconductor wafers, in which a multiplicity of semiconductor wafers polished at least on their front sides are prepared and successively coated individually by applying an epitaxial layer onto their polished front sides by chemical vapor deposition at temperatures of 800-1200°C in an epitaxial reactor, by respectively supporting one of the prepared semiconductor wafers on a device for supporting a semiconductor wafer during the deposition of a layer on a front side of the semiconductor wafer by chemical vapor deposition in an epitaxial reactor, containing a susceptor which has a gas-permeable structure and a ring, placed on the susceptor, which acts as a thermal buffer between the susceptor and the supported semiconductor wafer, so that the semiconductor wafer rests on the ring, its backside faces a bottom of the susceptor having a gas-permeable structure but does not touch the susceptor, so that gaseous substances are delivered from a region over the backside of the semiconductor wafer by gas diffusion through the susceptor into a region over the backside of the susceptor, and furthermore the semiconductor wafer comes in contact with the ring only in the edge region of its backside, with no stresses measurable by means of photoelastic stress measurement ("SIRD") occurring in the semiconductor wafer.

FIG. 1