

Method for producing semiconductor wafers with epitaxial layer in a chamber of a deposition reactor

5 The subject of the invention is a method for producing semiconductor wafers with epitaxial layer in a chamber of a deposition reactor by means of vapour deposition. A method of this kind is typically interrupted from time to time for the chamber to be maintained, more particularly for removal of material deposited on internal walls of the chamber. The condition of the chamber after such removal is not yet such as to allow
10 the coating therein of semiconductor wafers conforming to the expectations, particularly in terms of the required lifetime of minority charge carriers in the epitaxial layer. The chamber therefore requires conditioning, and this limits the productivity of the method.

15 Prior art / Problems

US 2008 0 219 824 A1 describes a typical plant which can be used to implement a method for producing semiconductor wafers with an epitaxial layer by means of vapour deposition. Such a plant generally comprises a plurality of deposition reactors, a load lock chamber and a transfer chamber. In particular, a deposition reactor
20 comprises an upper dome, a lower dome, a base ring, and an upper and a lower clamp ring, which belong commonly to a chamber in which the vapour deposition takes place. Located in the chamber in particular are a susceptor support shaft with support arms, a wafer lift shaft and a susceptor. The susceptor support shaft and the wafer lift shaft are connected to a rotating/lifting unit. Disposed above the upper dome
25 and below the lower dome are lamp modules and reflectors, to allow radiant energy to be provided in the chamber during the vapour deposition.

DE 11 2016 003 399 T5 suggests purging the chamber of a deposition reactor with nitrogen for conditioning in the plant, heating the inside of the chamber, and deciding,
30 via measurement of the lifetime of minority charge carriers on test wafers, whether the production of semiconductor wafers with epitaxial layer can be continued.

The chamber conditioning performed in this way significantly limits the productivity of the production of semiconductor wafers with epitaxial layer.

It is an object of the present invention to reduce such limitation and to propose
5 particularly effective conditioning.

The object of the invention is achieved by means of a method for producing semiconductor wafers with epitaxial layer in a chamber of a deposition reactor of a plant, comprising
10 repeatedly depositing an epitaxial layer on a substrate wafer in the chamber of the deposition reactor, producing a first number of semiconductor wafers with epitaxial layer, and at the same time conditioning a replacement chamber of the deposition reactor outside the plant by purging the replacement chamber with a purge gas;
15 interrupting the repeated deposition of an epitaxial layer on a substrate wafer; replacing the chamber by the replacement chamber; and continuing the repeated deposition of an epitaxial layer on a substrate wafer in the replacement chamber of the deposition reactor, producing a second number of semiconductor wafers with epitaxial layer.

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The time of limited productivity due to conditioning of the chamber is significantly reduced when using the process according to the invention and is accounted for in particular by the time taken to replace the chamber by the replacement chamber. Following replacement, the chamber replaced by the replacement chamber itself
25 becomes a replacement chamber, which can be conditioned outside the plant. The plant comprises a deposition reactor, preferably at least one further deposition reactor.

Constituents of a replacement chamber comprise preferably an upper dome, a lower
30 dome, a base ring, an upper and a lower clamp ring, a susceptor support shaft with support arms, a wafer lift shaft, a susceptor, a lower lamp module with lower reflectors, and a rotating/lifting unit for the shaft. The way in which these constituents are assembled during the conditioning of the replacement chamber is the same as

during vapour deposition. An upper lamp module with upper reflectors may optionally likewise be a constituent of the replacement chamber.

5 The conditioning of the replacement chamber is performed outside the plant, on a conditioning stand, and comprises the purging of the replacement chamber with a purge gas, and preferably one or two further measures. The purge gas is passed through the replacement chamber from at least one gas inlet to at least one gas outlet. The fraction of water in the purge gas on entry of the purge gas into the replacement chamber is preferably less than 100 ppm, more preferably less than 10 50 ppm. Furthermore, the purge gas is preferably free from particles, more particularly free from metallic particles.

The purge gas is nitrogen, hydrogen, helium, argon or a mixture of at least two of the stated gases. The use of nitrogen as purge gas is preferred. During purging of the 15 replacement chamber, care should be taken to ensure that as far as possible there are no dead spots in the interior of the replacement chamber at which the flow rate of the purge gas decreases in such a way that it drops off completely.

The further measures include increasing the temperature in the interior of the 20 replacement chamber in comparison to the temperature of the surroundings of the replacement chamber, this being done by means, for example, of IR radiation, heat mats or heat exchangers, or a combination thereof. The temperature at points on the constituents of the replacement chamber where there is contact with the interior of the replacement chamber is preferably more than 21°C, more preferably more than 65°C. 25 Towards the upper end the temperature is limited in principle only by the thermal stability of the material which is being heated.

The further measures also include changing of the pressure in the interior of the replacement chamber during conditioning, in which case the change in pressure may 30 be performed in two different ways. Firstly, by lowering the pressure in the interior of the replacement chamber in comparison to the pressure on the conditioning stand, or secondly by increasing the pressure in the interior of the replacement chamber in comparison to the pressure on the conditioning stand. The pressure may be lowered using valves and/or a vacuum pump at the gas outlet of the replacement chamber.

It is also possible, furthermore, to carry out a combination of the two kinds of pressure changes, for example by first increasing the pressure of purge gas in the interior of the replacement chamber and subsequently lowering said pressure below the pressure at the conditioning stand by drawing off the purge gas at the gas outlet.

The conditioning of the replacement chamber is performed for a predetermined time or, preferably, until the fraction of water in the purge gas on departure from the replacement chamber is at or below a predetermined threshold value. For this purpose, it is possible to measure the humidity in the purge gas at – for example – the gas outlet of the replacement chamber.

After conditioning, the replacement chamber may be sealed, in order to prevent the surrounding atmosphere from entering the interior of the replacement chamber as it is transported to the plant. The pressure difference between the pressure in the interior and the pressure in the surroundings of the sealed replacement chamber ought to be extremely small during the transport of the replacement chamber to the plant, in order to prevent possible implosion of the replacement chamber. Replacement of the chamber by the conditioned replacement chamber ought then to take place in an atmosphere of dry purge gas, in order to prevent humidity entering the replacement chamber while the chambers are being switched.

Alternatively, the transport of the chamber to the plant and its replacement may take place with continued purging of the replacement chamber with dry purge gas, so that there is no pressure difference between the interior and the surroundings. In this case a flow rate of 3 NI/min to 8 NI/min is advisable.

The semiconductor wafers produced in accordance with the invention consist preferably of silicon or comprise silicon substrate wafers with at least one epitaxial layer of silicon-germanium or at least one epitaxial layer of gallium nitride. The diameter of the semiconductor wafers is preferably at least 200 mm, more preferably 300 mm.

The invention is elucidated further below with reference to the drawings.

Brief description of the figures

- 5 **Fig. 1** shows a scheme of the conditioning of a replacement chamber on a conditioning stand according to one embodiment of the invention.
Fig. 2 shows the result of a comparison of lifetime measurements on semiconductor wafers with epitaxial layer.

10 **List of reference numerals used**

- 1 Replacement chamber
- 2 Lamp module
- 3 Rotating-lifting-unit
- 15 4 Gas supply
- 5 Valve
- 6 Pump
- 7 Heater
- 8 Measuring apparatus

20 Detailed description of exemplary embodiments according to the invention

- The replacement chamber 1 comprises constituents in the form of an upper dome, a lower dome, a base ring, an upper and a lower clamp ring, a susceptor support shaft with support arms, a wafer lift shaft and a susceptor. Further constituents are a lower
25 lamp module 2 having lower reflectors, and a rotating-lifting unit 3 for the shafts. Dry purge gas is passed through the replacement chamber 1 by means of the gas supply 4, with the volume flow of gas being adjusted by valves 5 at the gas inlet and the capacity of a pump 6 of the gas outlet. The scheme additionally provides for the temperature in the interior of the replacement chamber 1 to be increased by means of
30 a heater 7, and for the humidity of the purge gas after departure from the replacement chamber 1 to be determined by means of a measuring apparatus 8.

An epitaxial layer of silicon was deposited on substrate wafers composed of monocrystalline silica. After the production, respectively, of a first number of semiconductor wafers with epitaxial layer, in the case of a comparative example, the chamber in the deposition reactor was replaced by a different chamber and the different chamber was conditioned in the deposition reactor by purging with purged gas, and, in the case of an inventive example, a replacement chamber was conditioned in accordance with the present invention. Thereafter, respectively, a second number of semiconductor wafers with epitaxial layer was produced – the semiconductor wafers of the comparative example in the different chamber, and the semiconductor wafers of the inventive example in the replacement chamber. Afterwards, lifetime measurements of minority charge carriers were performed on the semiconductor wafers produced after conditioning, by means of μ -PCD (microwave photoconductivity decay, a.u. = arbitrary units).

Fig. 2 shows the result of the measurements for a number N of the semiconductor wafers of the comparative example (dashed curve) and of the inventive example (continuous curve), respectively. The values for the lifetime were higher at the start for the semiconductor wafers produced in accordance with the invention, and immediately show an increasing trend.

The above description of illustrative embodiments should be understood as representing examples. The resultant disclosure on the one hand enables the skilled person to understand the present invention and its associated advantages, and on the other hand, within the understanding of the skilled person, also embraces obvious adaptations and modifications of the structures and methods described. The intention is therefore that all such adaptations and modifications, and also equivalents, are to be covered by the scope of protection of the claims.

Claims

1. Method for producing semiconductor wafers with epitaxial layer in a chamber of a deposition reactor of a plant, comprising repeatedly depositing an epitaxial layer on a substrate wafer in the chamber of the deposition reactor, producing a first number of semiconductor wafers with epitaxial layer, and at the same time conditioning a replacement chamber of the deposition reactor outside the plant by purging the replacement chamber with a purge gas; interrupting the repeated deposition of an epitaxial layer on a substrate wafer; replacing the chamber by the replacement chamber, wherein after the conditioning the replacement chamber is sealed and transported in a closed state to the plant or after the conditioning the replacement chamber is transported to the plant and in this process purge gas is passed through the replacement chamber; and continuing the repeated deposition of an epitaxial layer on a substrate wafer in the replacement chamber of the deposition reactor, producing a second number of semiconductor wafers with epitaxial layer.
2. Method according to Claim 1, characterized in that the purge gas is passed through the replacement chamber, and a fraction of water in the purge gas on entry into the replacement chamber is less than 50 ppm.
3. Method according to Claim 1 or Claim 2, characterized in that the purge gas used comprises nitrogen, hydrogen, helium, argon or a mixture of at least two of the stated gases.
4. Method according to any of Claims 1 to 3, characterized in that during the conditioning of the replacement chamber, the temperature in the interior of the replacement chamber is increased in comparison to the temperature of the surroundings of the replacement chamber.
5. Method according to any of Claims 1 to 4, characterized in that during the conditioning of the replacement chamber, the pressure in the interior of the replacement chamber is changed at least once in comparison to the pressure in the surroundings of the replacement chamber.

6. Method according to any of Claims 1 to 5, characterized in that a humidity of the purge gas is measured after departure from the replacement chamber and the conditioning of the replacement chamber is continued for as long as the humidity is not yet at or below a predetermined threshold value.