

Apparatus and method for depositing a layer of semiconductor material on a substrate wafer

5 The subject of the invention is an apparatus for depositing a layer of semiconductor material on a substrate wafer by deposition from the vapor phase. A further subject of the invention is a method employing the apparatus.

Prior art/problems

10 Demanding applications in the field of the production of base material for the electronic industry include the deposition of a layer of semiconductor material on a substrate wafer, more particularly the deposition of an epitaxial layer on the substrate wafer.

15 During the deposition of the layer, the substrate wafer lies at deposition temperature on a susceptor. Process gas is passed over the upper side face of the substrate wafer, and cleavage products of a chemical compound (precursor) contained in said gas crystallize as a layer of material on the side face.

20 Apparatuses such as, for example, the single-wafer reactor described in US 2009 314 205 A1 are particularly suitable for the stated purpose. Said reactor possesses a base ring, which is disposed between an upper and a lower dome. Together they form a reaction chamber which houses a susceptor that carries the substrate wafer during the deposition of the layer of semiconductor material. The
25 substrate wafer is transported into the reaction chamber through a slit valve door and a slit valve tunnel. The process gas is passed by gas supply lines from a gas inlet to a gas outlet. The substrate wafer is brought to deposition temperature by means of thermal radiation.

30 The base material for the electronics industry must contain very low levels of extraneous substances that can impact the function of electronic components. Such substances include, in particular, metallic impurities. In order to fulfil this requirement even under the prevailing deposition conditions, such as the deposition temperature,

apparatus constituents such as the base ring, the gas inlet, the gas outlet, the gas supply lines, the outgoing gas lines (including bellows and cone), the slit valve door, and the slit valve tunnel consist in general of stainless steel.

- 5 Although stainless steel is considered to be particularly corrosion-resistant, it is desirable to prevent very largely the possibility of metallic impurities such as iron from the stainless steel from entering the layer of semiconductor material which is deposited on the substrate wafer.
- 10 The problem addressed by the invention is solved by means of an apparatus for depositing a layer of semiconductor material on a substrate wafer, comprising a base ring between an upper and a lower dome;
a susceptor as carrier of the substrate wafer during the deposition of the layer;
a gas inlet and a gas outlet, and gas supply lines for passing process gas over an
15 upper side face of the substrate wafer;
a slit valve tunnel and a slit valve door; and
a lifting and rotating means for lifting and turning the susceptor and the substrate wafer,
wherein one or more apparatus constituents consisting of stainless steel are covered
20 with an amorphous layer which comprises silicon and hydrogen.

- 25 It has been found that certain amorphous coatings for stainless steel are particularly suitable for the intended protection of the substrate wafer with deposited layer of semiconductor material with respect to impurities. These are coatings for stainless steel that are themselves generated by means of thermally induced chemical gas vapor deposition and comprise silicon and hydrogen.

- 30 At least one apparatus constituent which consists of stainless steel is preferably coated with the coating for stainless steel, at least on a face which is exposed to the process gas during the deposition of the layer of semiconductor material on the substrate wafer. Preferably at least one constituent such as the base ring, the gas inlet, the gas outlet, the gas supply lines, the slit valve door, the slit valve tunnel, and the lifting and rotating unit for lifting and turning a susceptor and the substrate wafer is coated with this coating. It is more preferred if all or virtually all of the apparatus

constituents which are made from stainless steel and which come into contact with process gas under the deposition conditions are covered with the coating for stainless steel.

5 The coating preferably comprises hydrogenated amorphous silicon ($a\text{-Si:H}$) or ($a\text{-Si}_x\text{C}_{1-x}\text{:H}$), more preferably a functionalized silicalike coating ($a\text{-SiO}_x\text{:CH}_y$). A hydrogenated amorphous silicon coating on stainless steel is available, for example, under the brand name Silcolloy[®] from SilcoTek Corp. and under the brand name SilCor[®]SiC from PT&B SILCOR GmbH, and a functionalized silicalike coating under
10 the brand name Dursan[®] likewise from SilcoTek Corp. The stainless steel is coated preferably by CVD (chemical vapor deposition) or PCVD (plasma-activated CVD). A method of this kind for placing such a coating on stainless steel is described in EP 2 988 327 A1, for example.

15 A further subject of the invention is a method for depositing an epitaxial layer of semiconductor material on a substrate wafer, where the substrate wafer is coated with the epitaxial layer in an apparatus having the properties described above.

The substrate wafer is preferably a semiconductor wafer of monocrystalline silicon, on
20 which a layer of monocrystalline silicon is deposited epitaxially under standard pressure. The deposition temperature is preferably 1000°C to 1300°C. The substrate wafer and/or the epitaxial layer may have been doped with an electrically active dopant. The type of dopant (p-type, n-type) may be the same or different. The substrate wafer preferably has a diameter of at least 200 mm, more preferably of at
25 least 300 mm.

In the description below, drawings are referenced.

Fig. 1 shows a number of features of the apparatus with which the invention is
30 concerned, in a sectional representation.

Fig. 2 shows the results of lifetime measurements of minority charge carriers by means of μPCD measurement (microwave photoconductivity decay).

List of symbols:

- 1 upper dome
- 2 lower dome
- 3 apparatus
- 5 4 substrate wafer
- 5 5 susceptor
- 6 lamps
- 7 base ring
- 8 gas inlet for process gas
- 10 9 gas inlet for purge gas
- 10 10 gas outlet for process gas
- 11 gas outlet for purge gas
- μ PCD lifetime values measured by μ PCD measurement
- N number of measured substrate wafers with deposited epitaxial layer

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Fig. 1 shows a number of features of the apparatus with which the invention is concerned, in a sectional representation. The apparatus 3 comprises a base ring 7, an upper and a lower dome 1, 2. Disposed above the upper dome 1 and below the lower dome 2 are lamps 6, for heating the substrate wafer to deposition temperature. During the deposition of a layer, the substrate wafer 4 lies on a susceptor 5, which is itself carried by susceptor carrier arms. The susceptor carrier arms are part of a lifting and rotating means for lifting and turning the susceptor and the substrate wafer. Process gas is introduced into the apparatus 3 via gas supply lines and through a gas inlet 8, and passed out of the apparatus through a gas outlet 10. Furthermore, the embodiment shown comprises a further gas inlet 9 and a further gas outlet 11, for passing purge gas through the region below the susceptor during the process of depositing the layer on the substrate wafer.

Exemplary embodiment:

30 The exemplary embodiment shows that a useful effect is observable even when the use of coated stainless steel constituents is confined to the use of coated gas supply lines and a coated outgoing gas line. An epitaxial layer of monocrystalline silicon was deposited on monocrystalline silicon substrate wafers having a diameter of 300 mm, in a Epi 300 Centura[®] apparatus from Applied Materials, Inc. During an experimental

series, the faces of the gas supply lines that come into contact with process gas, and the first meter of the outgoing gas line (including bellows and cone), were coated with a layer of Dursan[®], whereas a second experimental series were coated with silicon dioxide and, during a third experimental series, uncoated in the original condition with a surface of stainless steel. At the beginning of each experimental series, the apparatus was in the freshly maintained state.

After the deposition of the epitaxial layer, the lifetime of minority charge carriers was determined by means of μ PCD on the product wafers.

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In Fig. 2 the measured μ PCD values are plotted against the number N of the measured substrate wafers with a deposited epitaxial layer. In the case of the substrate wafers with epitaxial layer produced in accordance with the invention, longer lifetimes were measured, and an applied threshold value (dashed line) was attained more quickly, suggesting the conclusion that fewer impurities such as iron have been released and taken up in the epitaxial layer.

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What is claimed is:-

1. An apparatus for depositing a layer of semiconductor material on a substrate wafer, comprising
 - 5 a base ring between an upper and a lower dome;
 - a susceptor as carrier of the substrate wafer during the deposition of the layer;
 - a gas inlet and a gas outlet, an outgoing gas line and gas supply lines for passing process gas over an upper side face of the substrate wafer;
 - a slit valve tunnel and a slit valve door; and
 - 10 a lifting and rotating means for lifting and turning the susceptor and the substrate wafer,
 wherein one or more apparatus constituents consisting of stainless steel are covered with an amorphous layer which comprises silicon and hydrogen.
- 15 2. The apparatus as claimed in claim 1, wherein the stainless steel constituents are the base ring, the gas inlet, the gas outlet, the gas supply lines, the outgoing gas line including a bellows and a cone, the slit valve tunnel, the slit valve door, and the lifting and rotating means.
- 20 3. The apparatus as claimed in claim 1 or claim 2, which is configured as a single-wafer reactor.
4. The apparatus as claimed in any of claims 1 to 3, which is designed for depositing an epitaxial layer on the substrate wafer under standard pressure.
- 25 5. A method for depositing an epitaxial layer of semiconductor material on a substrate wafer, which comprises coating the substrate wafer in an apparatus as claimed in any of claims 1 to 4 with the epitaxial layer.