

**Retainer, method for producing same
and use thereof**

The invention relates to a retainer, a method for
5 producing the retainer, and the use of same.

In the production of semiconductor components, in
particular of silicon solar cells, plasma-driven vapor
depositions are often carried out, this being referred
10 to by English speakers in the jargon as plasma-enhanced
chemical vapor deposition (PECVD). In this case, the
semiconductor substrates to be coated are usually
arranged in retainers. So-called boats are regularly
used as retainers in PECVD depositions.

15

In the industrial manufacture of silicon solar cells,
silicon solar cell substrates are often arranged in
said boats, which in some instances are also referred
to as PECVD boats, and are provided with an
20 antireflection layer composed of silicon nitride in the
context of a PECVD deposition. Homogeneous
antireflection layers are only obtained, however, if
the boat used has already been provided with a silicon
nitride layer beforehand. Usually, therefore, the boats
25 used are coated with silicon nitride in the context of
a so-called silicon nitride precoating before a coating
of solar cell substrates arranged in the boats with
silicon nitride is carried out. Graphite is usually
used as material for the boats. The requirement of the
30 silicon nitride precoating is possibly attributable to
the fact that the electrical surface resistances of
graphite and the silicon solar cell substrates are too
different. However, morphological or chemical reasons,
the porosity of the boat material or the grain size
35 constitution thereof may also play a part. The causes
have not been definitively clarified at the present
time.

Since silicon nitride as dielectric has an electrically insulating effect and the PECVD deposition of silicon nitride on the silicon solar cell substrates necessitates an electrically conductive contact between
5 the boat and the silicon solar cell substrates arranged therein, during the silicon nitride precoating those regions in which the silicon solar cell substrates bear against the boat have to be omitted from the silicon nitride precoating. This is usually realized by
10 arranging silicon substrates in these regions during the silicon nitride precoating, which silicon substrates are usually referred to as dummy wafers and in said regions largely prevent a silicon nitride deposition on holding lugs or sections of the boat
15 surface that are covered by the dummy wafers. In this case, holding lugs should be understood to mean projections on the surfaces of the boats at which the silicon solar cell substrates are supported. The holding lugs make a significant contribution to the
20 electrical contacting since, during silicon nitride depositions, the silicon substrates often do not bear with sufficient area against the boat used.

If oxygen-containing gases are present in a PECVD
25 deposition, for example when nitrous oxide or nitrogen monoxide is used as process gas, then the silicon nitride precoating cannot prevent a decomposition of the boats in those regions which were shielded by the dummy wafers during the silicon nitride precoating.
30 This holds true in the same way for other retainers, such as susceptors used for example in rapid processing installations, so-called rapid thermal processing (RTP) installations. The described decomposition in oxygen-containing process gas atmospheres leads to wear of the
35 retainer used.

Therefore, the present invention is based on the object of providing a retainer which has improved wear

resistance in oxygen-containing process gas atmospheres.

5 This object is achieved by means of a retainer having the features of claim 1.

Furthermore, the invention is based on the object of enabling an outlay-expedient coating of substrates.

10 This object is achieved by means of a use of the retainer according to the invention as claimed in claim 8.

15 Furthermore, the invention is based on the object of providing an outlay-expedient method for producing the retainer according to the invention.

This object is achieved by means of a method having the features of claim 11.

20 Dependent claims respectively relate to advantageous developments.

25 The retainer according to the invention has a coating composed of silicon carbide, glassy carbon or pyrolytic carbon on its surface.

30 With retainers coated in this way, it is possible to realize an increased wear resistance in oxygen-containing process gas atmospheres. This is the case particularly for oxygen-containing process gas atmospheres which are formed using nitrous oxide and/or nitrogen monoxide as process gases.

35 The stated coating materials can be applied, in principle, in any manner known per se. A coating composed of glassy carbon can be applied, for example, by an alcohol bath being admixed with phenolic resin

powder and the article that is to be coated being immersed in the resulting solution. Afterward, the article to be coated is heated to a temperature of at least 600°C. This procedure has proved to be worthwhile particularly in the case of articles to be coated which are composed of graphite.

A coating composed of silicon carbide is preferably provided. Silicon carbide is abrasion-proof and resistant to hydrofluoric acid. In most applications, therefore, a post-coating with silicon carbide is required only very rarely. Furthermore, silicon carbide adheres well on graphite, which is a customary material for retainers used in semiconductor technology. Furthermore, it has been found that graphite bodies having a silicon carbide coating have an electrical surface resistance similar to that of silicon solar cell substrates. This appears to have an advantageous effect on the properties of layers deposited on silicon solar cell substrates by means of PECVD methods. However, morphological or chemical reasons or the porosity or the grain size constitution of graphite may also play a part here. It has been found at any rate that the silicon nitride precoating described in the introduction can be omitted in the case of silicon-carbide-coated retainers, particularly in the case of silicon-carbide-coated boats, without the homogeneity of a silicon nitride layer deposited using such a retainer, for example of an antireflection coating, being impaired thereby to a relevant extent. Since silicon carbide is electrically conductive, in addition the dummy wafers described above are not required. In the industrial manufacture of silicon solar cells, the requirement for dummy wafers is a non-negligible cost factor, and so the use of the retainer according to the invention and the associated obviation of the requirement for dummy wafers enable the manufacturing outlay to be reduced.

Silicon carbide or a silicon carbide coating in the present case should be understood to mean that the material used or the coating concerned substantially
5 consists of silicon carbide. A complete purity of the material is not necessary. Impurities, foreign material inclusions at interfaces or the like can be present in amounts that are customary in practice.

10 If retainers according to the invention are used in silicon nitride depositions, then silicon nitride is also deposited on the retainer used. After a certain number of depositions, silicon nitride parts spall off from the retainer. This can adversely affect the
15 quality of the silicon nitride layer which is deposited on an object arranged in the retainer. For this reason, retainers of silicon nitride deposition installations are usually subjected to etching-back after a certain number of depositions. It has been found that with the
20 use of a retainer according to the invention, the number of possible depositions before a next etching-back step is necessary can be increased compared with retainers known heretofore. This is the case particularly for retainers which have a coating
25 composed of silicon carbide. The higher number of silicon nitride depositions that can be carried out with a retainer until the next etching-back process enables a further reduction of the manufacturing outlay in industrial application, for example in industrial
30 solar cell manufacture.

If the retainer is provided with a coating composed of pyrolytic carbon, then this results in an improved resistance toward oxygen and oxygen radicals compared
35 with a coating with glassy carbon at high temperatures of up to 1100°C. A pyrolytically deposited carbon layer can be combined with pyrolytically deposited carbon by means of an infiltration. Such a combination adheres

very well on graphite and is very impermeable. Furthermore, it has a significantly harder surface and is more resistant toward oxygen and oxygen radicals compared with a simple pyrolytically deposited carbon layer. Such retainers accordingly exhibit greater wear resistance toward mechanical stresses and are more resistant toward decomposition in oxygen-containing process environments.

One development provides for the retainer to consist predominantly of graphite or glass. Preferably, it consists of graphite or glass completely, apart from the coating. Said glass can be a quartz glass, in particular. In practice, particularly in the production of semiconductor components, graphite has proved to be particularly worthwhile, for which reason this material is particularly preferred.

The coating is advantageously arranged directly on a core material of the retainer. Precoatings or intermediate coatings can be obviated in this way.

Advantageously, the coating extends over the entire surface of the retainer, such that the increased resistance to wear is present across the entire surface of the retainer. If the retainer is embodied as a graphite boat, then the coating preferably extends over all electrically conductive surface portions of the graphite boat.

In one particularly preferred configuration variant, the coating provided is a silicon carbide coating having a thickness of less than 25 μm . Preferably, the thickness is less than 10 μm and, particularly preferably, the thickness has a maximum value of 10 μm and a minimum value of 1 μm . In the last-mentioned case, the thickness of the silicon carbide coating thus varies in an interval having a lower interval limit of

1 μm and an upper interval limit of 10 μm . It has been found that the wear resistance of the retainer can be increased particularly efficiently in the case of silicon carbide coatings configured in this way.

5

In one configuration variant, the retainer is embodied as a boat for vapor deposition installations. The vapor deposition installations can be physical vapor deposition (PVD) or chemical vapor deposition (CVD) installations. The boat is preferably suitable for receiving silicon substrates. Particularly preferably, the boat is designed in such a way that it is suitable for use in PECVD installations.

15 In another embodiment variant, the retainer is embodied as a susceptor for RTP furnaces. RTP furnaces should be understood here to mean furnaces which are suitable for the rapid thermal processing of articles, in particular of semiconductor substrates. RTP furnaces are often heated by means of halogen lamps and enable the article to be heated very rapidly.

The use according to the invention provides for a retainer embodied as a boat for vapor deposition installations to be used as a retainer for substrates in a plasma-driven vapor deposition. In this way, the substrates can be coated in an outlay-expedient manner since the retainer has an increased resistance to wear in an oxygen-containing process gas atmosphere.

30

The retainer is preferably used for silicon substrates, and particularly preferably used for silicon solar cell substrates. In this way, particularly with the use of boats for which the coating is formed from silicon carbide, in the case of a silicon nitride deposition, a silicon nitride precoating can be dispensed with and use of dummy wafers can be omitted. This substantive matter has already been explained in greater detail

above in connection with the retainer. As a result, therefore, silicon substrates, or silicon solar cell substrates, can be coated in a more outlay-expedient manner.

5

Advantageously, therefore, in the plasma-driven vapor deposition, silicon nitride or silicon oxynitride is deposited on the substrates, preferably silicon nitride. Particularly in a deposition on silicon
10 substrates, or silicon solar cell substrates, a significant reduction of the manufacturing outlay can be brought about in this way.

On account of the increased wear resistance of the
15 retainer in an oxygen-containing process gas atmosphere, the boat can be used particularly advantageously in those PECVD depositions in which an oxygen-containing process gas atmosphere is formed at least temporarily. Particularly in the case of use of
20 graphite boats, this is advantageous since the wear thereof can be reduced in this way. In PECVD silicon oxide depositions, the use of the boat has therefore proved to be advantageous.

25 According to current knowledge, the advantages afforded by the use according to the invention are established independently of whether the coating is carried out approximately at atmospheric pressure or lower pressure values, independently of whether an ionic or radical
30 coating type is involved and also independently of the plasma frequency used. The use according to the invention has proved to be particularly worthwhile in conjunction with plasma frequencies of less than 400 kHz and especially preferably in conjunction with a
35 plasma frequency of 40 kHz and in conjunction with a plasma frequency of 13.56 kHz or 2.45 GHz.

The method for producing a retainer according to the invention provides for depositing silicon carbide as a coating on a volume material of the retainer by means of a chemical vapor deposition.

5

In the present case, the term volume material should be understood to mean the material of which the retainer consists before the coating is applied. If the retainer does not consist of a uniform material before the
10 coating is applied, the term volume material thus encompasses all materials of which the retainer consists at this point in time, with the exception of joining parts such as, for example, spacer elements or connecting elements. In particular, possible additional
15 coatings already applied beforehand are included.

By means of the method described, the retainer can be provided with the coating in an outlay-expedient manner. This is the case particularly if the retainer
20 is provided for use in a CVD installation. This is because in this case said CVD installation, which can be embodied for example as a PECVD installation, can be used both for coating the retainer and for coating articles arranged in the retainer later. Said articles
25 can be substrates, for example. Such a coating of the retainer with silicon carbide is significantly more outlay-expedient than an external CVD deposition. Already existing CVD, or PECVD, installations generally only have to be slightly modified in order to enable
30 the silicon carbide deposition. In the case of a PECVD installation already set up for a silicon nitride deposition, by way of example, it is merely necessary additionally to provide a feed device for methane.

35 Advantageously, the coating is deposited on a volume material which predominantly, preferably completely, consists of graphite or glass. These materials have proved worthwhile in practice and can be used as

retainers in many applications, in particular in applications of semiconductor component fabrication. Particularly preferably, a volume material which predominantly or completely consists of graphite is coated, since this material is generally better suited to use in PECVD installations on account of its electrical conductivity.

The deposition of the silicon carbide is preferably carried out by means of a plasma-driven vapor deposition, or in other words by means of a PECVD deposition. For the deposition, advantageously a direct plasma is formed on a surface of the retainer. This has proved to be advantageous particularly if the direct plasma is formed on a graphite surface.

For the deposition of the silicon carbide, a plasma formed using methane and silane can be used. A plasma formed from methane and silane is preferably used.

In one advantageous embodiment variant, the deposited silicon carbide is densified. This can be brought about by means of an ion bombardment, for example, and is particularly preferably realized by means of a plasma. A low-frequency plasma having a plasma frequency of less than 400 kHz has proved to be particularly worthwhile in this context.

The invention is explained in greater detail below with reference to figures. Insofar as appropriate, identically acting elements are provided with identical reference signs herein. The invention is not restricted to the exemplary embodiments illustrated in the figures - not even with regard to functional features. The description above and also the following description of figures contain numerous features which are reproduced in a manner combined as a plurality in part in the dependent claims. However, these features and all the

other features disclosed above and in the following description of figures will be considered individually and combined to form expedient further combinations by the person skilled in the art. In particular, these
5 features can be combined in each case individually and in any suitable combination with the retainer and/or the method and/or the use as claimed in the independent claims. In the figures:

10 figure 1 shows one exemplary embodiment of a retainer embodied as a boat for vapor deposition installations in a schematic illustration

figure 2 shows one exemplary embodiment of a retainer embodied as a susceptor for RTP furnaces in a
15 schematic illustration

figure 3 shows a schematic partial sectional illustration through the retainer in accordance with figure 2 or through the
20 retainer from figure 1

figure 4 shows one exemplary embodiment of the method according to the invention
25

figure 5 shows one exemplary embodiment of the use according to the invention.

Figure 1 illustrates one exemplary embodiment of a
30 retainer embodied as a boat 10 for vapor deposition installations, for a PECVD installation in the present case, in a schematic perspective illustration. The boat 10 is suitable for receiving silicon substrates, and in particular silicon solar cell substrates, and is
35 composed of a plurality of plates 14a, 14b, 14c and further plates in a manner known per se. For receiving silicon substrates, three holding lugs 16 are provided for each of the silicon substrates.

In the exemplary embodiment in figure 1, the volume material of the boat 10, apart from insulators 15, consists of graphite on which a coating 12 composed of silicon carbide is arranged directly. Glassy carbon or pyrolytic carbon could also be provided instead of silicon carbide.

Apart from the insulators 15 used as spacers and thus as spacer elements, the coating 12 extends over the entire surface of the boat 10 and has a thickness of between 1 μm and 10 μm .

Figure 2 shows, in a schematic plan view illustration, one exemplary embodiment of a retainer embodied as a susceptor 50 for RTP furnaces in a schematic illustration. The susceptor 50 has a coating 12 composed of silicon carbide on its surface, said coating extending over the entire surface of the susceptor 52 and having a thickness of between 1 μm and 10 μm . Apart from the coating 52, the susceptor completely consists of graphite or glass. Instead of the coating 52 composed of silicon carbide, the coating can also be formed from glassy carbon or pyrolytic carbon.

The coating 52 is arranged directly on a volume material of the susceptor 50 which consists of graphite or glass in the manner mentioned. This is explained in greater detail below with reference to the illustration in figure 3.

Figure 3 shows a schematic partial sectional illustration through the susceptor 50 from figure 2, or through the boat 10 from figure 1. In the case of the boat 10 from figure 1, figure 3 could illustrate for example a partial section through the plate 14a. Figure 3 shows a volume material 60 provided with a

coating 62 on all surfaces. If figure 3 is regarded as a partial sectional illustration through the boat 10 from figure 1, then the coating 62 constitutes the silicon carbide coating 52 from figure 1 and the volume material 60 is graphite. On the other hand, if figure 3 is regarded as a partial sectional illustration through figure 2, then the coating 62 constitutes the coating 52 composed of silicon carbide and the volume material 60 is graphite or glass. In the exemplary embodiments in figures 1 to 3, the volume material 60 in each case also constitutes the core material of the boat 10 or of the susceptor 50. Precoatings or intermediate coatings are not present.

Figure 4 shows a basic illustration of one exemplary embodiment of the method according to the invention. In this method, firstly a retainer, for example a boat or a susceptor, is introduced 70 into a PECVD installation. Subsequently, a direct plasma is formed 72 on a surface of the retainer in the PECVD installation using silane and methane. A deposition 74 of silicon carbide is carried out by means of a plasma-driven vapor deposition. Furthermore, the deposited silicon carbide is densified 76 by ion bombardment. The ions used for this purpose are preferably plasma generated by means of a low-frequency plasma.

Figure 5 illustrates one exemplary embodiment of the use according to the invention in a basic illustration. In this case, a retainer embodied as a boat for vapor deposition installations is loaded with silicon solar cell substrates and introduced 90 into a PECVD installation. In said PECVD installation, an oxygen-containing process gas atmosphere is formed 92, in which, in the present exemplary embodiment, a silicon oxynitride layer is formed on the silicon solar cell substrates. Subsequently, a silane- and nitrogen-containing process gas atmosphere is formed and herein

silicon nitride in the form of a silicon-nitride-containing layer is deposited 93 on the silicon solar cell substrates. In the exemplary embodiment illustrated in figure 5, the boat used is the boat 10
5 illustrated in figure 1, said boat 10 being provided with a coating 12 composed of silicon carbide and comprising a volume material composed of graphite, such that the boat 10 is protected against premature wear in the oxygen-containing process gas atmosphere by the
10 coating 12 composed of silicon carbide. As explained above, in this embodiment variant it is possible to dispense with a silicon nitride precoating of the boat 10 and likewise with the use of dummy wafers involving high material outlay. The exemplary embodiment in
15 figure 5 thus enables an outlay-expedient coating of the silicon solar cell substrates with silicon nitride, for example as an antireflection coating.

List of reference signs

	10	boat
	12	coating
5	14a	plate
	14b	plate
	14c	plate
	15	insulator
	16	holding lugs
10		
	50	susceptor
	52	coating
	60	volume material
15	62	coating
	70	introducing retainer into PECVD installation
	72	forming plasma using silane and methane
	74	vapor deposition of silicon carbide
20	76	densifying silicon carbide by ion bombardment by means of the plasma
	90	loading boat with silicon solar cell substrates and introduction into PECVD installation
25	92	forming oxygen-containing process gas atmosphere and depositing silicon nitride
	93	forming silane- and nitrogen-containing process gas atmosphere and depositing silicon nitride

Patent claims

1. A retainer (10; 50),
characterized
5 in that the retainer (10; 50) has a coating (12;
52) composed of silicon carbide, glassy carbon or
pyrolytic carbon on its surface.
2. The retainer (10; 50) as claimed in claim 1,
10 characterized
in that the retainer (10; 50) consists of graphite
or glass predominantly, preferably completely
apart from the coating (12; 52).
- 15 3. The retainer (10; 50) as claimed in either of the
preceding claims,
characterized
in that the coating (62) is arranged directly on a
core material (60) of the retainer (10; 50).
20
4. The retainer (10; 50) as claimed in any of the
preceding claims,
characterized
in that the coating extends over the entire
25 surface of the retainer (50).
5. The retainer as claimed in any of the preceding
claims,
characterized
30 in that the coating (12; 52) provided is a silicon
carbide coating having a thickness of less than
25 μm , preferably of less than 10 μm , and in
particular preferably having a thickness having a
maximum value of 10 μm and a minimum value of
35 1 μm .
6. The retainer (10) as claimed in any of the
preceding claims,

characterized

in that the retainer (10) is embodied as a boat
(10) for vapor deposition installations, said boat
preferably being suitable for receiving silicon
substrates.

5

7. The retainer (50) as claimed in any of claims 1 to
5,

characterized

in that the retainer (50) is embodied as a
susceptor (50) for RTP furnaces.

10

8. The use (90, 92) of a boat (10) as claimed in
claim 6 in a plasma-driven vapor deposition as a
retainer (10) for substrates, preferably for
silicon substrates and particularly preferably for
silicon solar cell substrates.

15

9. The use (90, 92) as claimed in claim 8,

characterized

in that in the plasma-driven vapor deposition
silicon oxide, silicon oxynitride or silicon
nitride is deposited (92) on the substrates,
preferably silicon nitride.

20

25

10. The use (90, 92) as claimed in either of claims 8
and 9,

characterized

in that in the plasma-driven vapor deposition an
oxygen-containing process gas atmosphere is formed
(92) at least temporarily.

30

11. A method for producing a retainer (10; 52) as
claimed in any of claims 1 to 7,

characterized

in that by means of a chemical vapor deposition
(14) silicon carbide is deposited (14) as a

35

coating (12; 52, 62) on a volume material (60) of the retainer (10; 50).

- 5 12. The method as claimed in claim 11,
characterized
in that the coating (12; 52; 62) is deposited (14)
on a volume material (60) which predominantly,
preferably completely, consists of graphite or
glass.
- 10 13. The method as claimed in either of claims 11 and
12,
characterized
in that the deposition (14) is effected by means
15 of a plasma-driven vapor deposition.
14. The method as claimed in claim 13,
characterized
in that the plasma used for the deposition (14) is
20 embodied in the form of a direct plasma on a
surface of the retainer (10; 52) to be coated.
15. The method as claimed in either of claims 13 and
14,
25 characterized
in that a plasma formed (12) using methane and
silane is used for the deposition (14).
16. The method as claimed in any of claims 11 to 15,
30 characterized
in that the deposited silicon carbide is densified
(16), preferably by ion bombardment and
particularly preferably by means of a plasma.