Description

Method and device for treating a substrate surface of a substrate

Field of application and prior art

The invention relates to a method for treating a substrate surface in accordance with the preamble of claim 1, and to a device suitable for carrying out the method.

DE 10 2005 062 527 A1 and DE 10 2005 062 528 A1 disclose methods for treating planar substrates on one side, to be precise for treating the substrate undersides or the downwardly facing substrate sides. When this method is applied, it is possible here despite extraction by suction below the substrates, for the substrate top side to be slightly attacked by reaction gases or outgassings from the process medium, under certain circumstances also through direct contact. Moreover, depending on the transport speed of the substrates, the mixture of the process medium or the chemical and the state of the substrate surfaces, an undesired edge wraparound of the process medium can occur. As a result, the substrate top side can be attacked and also be impaired optically or, which is even worse, functionally.

Object and how it is achieved

The invention is based on the object of providing a method mentioned in the introduction and a corresponding device with which problems in the prior art can be eliminated and, in particular, a possibility is provided for preventing an upwardly facing substrate top side of the substrate from being exposed to the

undesirable and harmful effect of the process medium, in particular in outgassed form.

This object is achieved by means of a method comprising the features of Claim 1 and also a device comprising the features of Claim 16. Advantageous and preferred configurations of the invention are the subject matter of the further claims and are explained in greater detail below. Some of the features below are described only for the method or only for the device. However, irrespective of this they are intended to be applicable both to the method and to the device. The wording of the claims is incorporated by express reference in the content of the description.

It is provided that the substrate surface or the substrate underside is treated with a usually liquid process medium. The process medium has a removing or etching effect on the substrate surface, for example for the polish-etching or edge insulation of a silicon substrate for a solar cell. In this case, the substrates are wetted with the process medium from below in a manner lying horizontally which can be done in various ways known from the prior art. According to the invention, the upwardly facing or directed substrate top side is wetted or covered with water or some other corresponding protective liquid over a large area or advantageously even over the whole area. This acts as protection against the process medium or outgassings therefrom acting on or reaching the substrate top side; it can therefore as it were, be kept away therefrom. The water or the protective liquid therefore forms a protective layer on the substrate top side, such that the latter cannot be damaged by the process medium. The advantage of a liquid such as water or some other protective liquid as a protective layer or protective medium is that a liquid can easily be applied and can easily be removed again and does not

bring about any mechanical impairment of the substrate top side, that is to say scratching or the like. Furthermore, the water or generally the protective liquid can advantageously be chosen such that no reaction whatsoever with the substrate top side takes place, nor any other negative impairment. Finally, it is additionally possible for the water or the protective liquid to be coordinated with the choice of process medium in such a way that water or a corresponding protective liquid running down from the substrate top side can pass into the process medium and possibly indeed dilutes the latter. However, on account of the small quantity, only an insignificant and otherwise no negative impairment of the effect, generally of the etching effect, of the process medium is brought about. Even further explanations in this respect will be given below.

It is advantageously possible to apply the protective liquid to the substrate top side before the substrate or the substrate underside is wetted with the process medium. In particular, the application of the protective liquid is even effected before the substrate is moved over a tank with the process medium therein, that is to say temporally distinctly before that or on a transport path approximately half a metre or less upstream thereof. What can thereby be achieved is that protective liquid running down cannot actually pass into the tank with the process medium therein in the first place. For the customary time of a few seconds or a few minutes for which the treatment with the process medium above the tank lasts, a single application of protective liquid to the substrate top side may suffice.

In a further configuration of the invention, the protective liquid is applied to the moved substrates or the substrate top sides thereof in a continuous method.

This can advantageously be effected by means of a stationary application device in the form of spray nozzles or spray pipes, but advantageously with little pressure, for example also by means of surge pipes. A metering can easily be set for a desired quantity of liquid on the substrate top side or thickness of a liquid film.

Even though it may suffice in many cases to apply the protective liquid to the substrate top side only once, provision can advantageously be made for applying the protective liquid multiply or at time intervals to the substrate top side, or for renewing the protective film formed thereby. This can also be effected, for example, by the protective liquid being applied while the substrates run above the tank with the process medium therein. In this case, either application can be effected very precisely, such that as little protective liquid as possible passes into the tank, or a specific delimited region can be provided or the substrates are withdrawn again, although this is generally excessively complicated.

As an alternative, the protective liquid can be applied to the substrate top side only one single time, and this is in particular before the substrate is situated above the tank with the process medium therein. The protective liquid can be applied to the substrate top side in a controlled manner such that it is present only on substrate top side. This is possible by starting of the application only when a substrate is situated under an application device. In similar manner it is stopped when the substrate is still situated under the application device. Preferably the position or adjustment of an adducted substrate is detected by means of substrate sensors, and the application device is controlled depending on this. Alternatively the position of the substrates is calculated on the basis

of their application, and this can be passed on to a control device of the apparatus for the application nozzles. This way it is possible for a layer of the protective liquid to be formed, which will not drool down at the edge of the substrate, so that these may be treated with the process medium.

With correspondingly designed application devices mentioned above, in one configuration of the invention, the protective liquid can be applied to the substrate top side with a two-dimensionally distributed profile. For this purpose corresponding application devices can be designed, for example as spray nozzles, such that they produce a two-dimensionally distributed spray mist or, as surge pipes, a wide water screen. This is suitable, firstly for covering the substrate top sides with the protective liquid before movement over the tank with process medium. Furthermore, easy application of protective liquid is made possible if the latter has no negative interaction with the process medium.

As an alternative to a two-dimensional distributed application of the protective liquid to the substrate top side, this can be effected with a two-dimensionally distributed profile or in punctiform. This means, therefore, that from one or a few application devices, the protective liquid is sprayed or dropped onto the substrate top side in relatively punctiform fashion and then flows. The substrate surface can thus ultimately be covered over a large area or over the whole area, in which case, given known properties of the substrate top side, the temperature and also the properties of the protective liquid, the quantity thereof can be determined relatively precisely such that only a small proportion overflows over the substrate and can pass downwards into the process medium.

In the method it can be provided that when the substrate underside is wetted or treated with the process medium, an exothermic reaction takes place with a temperature increase of at least 10°C. A relatively thick layer of protective liquid can then advantageously be applied to the substrate top side, for example with a thickness of more than 0.5 mm or more than 1 mm, up to 1.5 mm in the case of water and even thicker in the case of protective liquids having a higher viscosity. As a result, a large portion of the protective liquid can evaporate as a result of the temperature increase and a sufficiently effective protective layer can still remain.

Alternatively, a temperature increase during the treatment of the substrate underside with the process medium can be omitted. A significantly smaller layer thickness for the protective liquid on the substrate top side then suffices, for example less than 0.2 mm or even less than 0.05 mm, actually just a thin film. However, it can have an abovementioned thickness in this case, too.

In a further configuration of the invention it can be provided that during treatment the substrate underside touches a liquid level of process medium in a tank, without the substrates being immersed more deeply. They can then as it were float on the surface of the process medium. In this case, without protective liquid, there may be the risk of process medium adhering to the edges of the substrate and possibly even reaching the substrate top side with corresponding negative consequences. Alternatively, the substrate underside can be sprayed with the process medium, although here the risk is even greater that the process medium sprayed upwards will pass upwards past the outer edges of the substrates and then settle on the substrate top sides at least in the edge regions. In the case of such

spraying of the substrate undersides with the process medium from below, it is even less critical if an excessively applied amount of protective liquid drips down from the substrate, since it is then not necessarily mixed with the process medium that is sprayed against the substrate underside. The protective liquid then possibly passes into a common collecting tank, that it can possibly be separated there or alternatively, by means of corresponding treatment here the process medium can be present with the desired concentration.

After the treatment of the substrates with the process medium, said substrates can be rinsed. In this case, it can be provided that the protective liquid is also rinsed or removed from the substrate top side.

Furthermore, in this case, in accordance with a further aspect of the invention such substrates which are pierced or have perforations can also be protected, as it were, during an etching process on the substrate underside, from the etching effect reaching the substrate top side. Primarily a region around the perforations is thereby jeopardised. Therefore, a substrate can be protected not only from an edge wraparound of the process medium or settling from above, but also from the process medium ascending through perforations, for example on account of capillary action.

Alongside water or pure water, an appropriate protective liquid is one having a higher viscosity. One example thereof is PEG having a viscosity with a factor of 2 to more than 3 above that of water, or for example also up to a factor of 3.8 in the case of phosphoric acid as protective liquid. The phosphoric acid can also specifically prevent a situation in which, on account of the concentration gradient, by way of example, an

etching solution comprising phosphoric acid and HF, in the case of pierced substrates, is drawn upwards not only by the capillary action but also on account of the concentration gradient, as would be present in the case of water.

Other protective liquids can have an even much higher viscosity for an even further improved protective effect or layer thickness. What is achieved by means of the higher viscosity is that the protective liquid is as it were somewhat less runny and does not run as easily from the substrate top side.

Preferably several application devices are provided neighbouring each other in a direction approximately transverse to a continuous-passage path of the substrates. The substrates can preferably be by laid onto the continuous-passage path in rows one after the other and each of them pass exactly under one application device.

In the device according to the invention it is actually provided that, above a continuous-passage path for the substrates, application devices are provided, advantageously in the form of nozzles. They can be arranged either exclusively upstream of the tank with the process medium therein, above the tank or both upstream of the tank and above the tank. The application devices are advantageously designed such that they can be adapted to the size, number of substrates alongside one another and also throughput speed such that protective liquid is applied to the substrate top sides only to the desired extent and not to excess or only insignificantly to excess.

Preferably at least one application device is arranged upstream of the tank with the process medium therein, wherein especially preferably one single row of

application devices is provided transverse to the continuous-passage path of the substrates. The application devices are distanced one from the other, wherein in particular their distance is at least one width of a substrate.

For providing the application devices with liquid the can be connected to a supply tank, which is situated higher than the application devices. In this way the afflux of protective liquid to the application devices with continuous pressure can be reached by gravity alone.

In an embodiment of the invention substrate sensors are provided upstream of the application devices, seen along the continuous-passage path of the substrates, for detection of a substrate being moved closer as well as for detection of a substrate moved in passing by. Preferably these are optical sensors.

These and further features emerge not only from the claims but also from the description and the drawings, wherein the individual features can in each case be realised by themselves or as a plurality in the form of subcombination in an embodiment of the invention and in other fields and can constitute advantageous and inherently protectable embodiments for which protection is claimed here. The subdivision of the application into individual sections and sub-headings do not restrict the general validity of the statements made thereunder.

Brief description of the drawings

Exemplary embodiments of the invention are schematically illustrated in the drawings and are explained in greater detail below. In the drawings:

Figure 1 shows a lateral sectional illustration of an apparatus according to the invention for the treatment of substrate undersides while water as protective film is applied to the substrate top sides,

Figure 2 shows an enlarged illustration from Figure 1, and

Figure 3 shows a top view of an alternative apparatus according to the invention with less application nozzles and with substrate-sensors upstream.

Detailed description of the exemplary embodiments

Figure 1 illustrates, as a device according to the invention, an apparatus 11 in lateral section comprising a tank 13, in which is situated etching solution 15 as process medium. From the left, substrates 20 with their substrate underside 21 facing downwards and a substrate top side 22 facing upwards are transported towards the right on a continuous-passage path composed of transport rollers 24. They then pass on the transport rollers 24 over the tank 13. As is known from DE 10 2005 062 527 A1 and DE 10 2005 062 528 A1 described in the introduction, in accordance with a first possibility, by means of the transport rollers 24 which reach into the etching solution 15 with their lower region, said etching solution 15 will be applied to the substrate undersides 21. Fresh or conditioned etching solution 15 is introduced into the tank 13 via a feed pipe 16. As an alternative or in addition to wetting of the substrate undersides 21 by means of the transport rollers 24, a spray pipe 17 can be provided, having an upwardly facing spray nozzle 18. Etching solution 15 can thus be sprayed onto the substrate undersides 21.

Furthermore, additionally in accordance with DE 10 2005 062 527 A1, means for suction extraction of gas that outgasses from the etching solution 15 can be provided above the surface of the etching solution and below the transport plane of the substrates.

Distinctly before the substrates 20 are introduced over the tank 13, they are sprayed with water by an application nozzle 26 arranged above them, said water forming a protective film 29 on the substrate top side 22. In this case, being sprayed with water 27 can advantageously be effected two-dimensionally or the application nozzle 26 can extend over the entire width of the substrate 20. Instead of the application nozzle, the nozzles of which can be at a distance of a few cm from one another, an abovementioned surge pipe with holes or slots can also be used. When the substrate 20 passes below the application nozzle 26, the entire substrate top side 22 is then sprayed or wetted with water 27 and a whole-area protective film 29 is thus formed. The advantage of spraying, particularly if it is effected over the whole area, in this case resides in the fact that it is then ensured that the entire substrate top side 22 is covered by the protective film 29. If the water 27 is intended to proceed merely from a single location, then it might happen that, by way of example, contaminated regions or the like on the substrate top side 22 are not wetted or covered and consequently not protected. Advantageously, three holes per substrate are provided on the application nozzle 26 or on the surge pipe.

If the etching solution 15 is then applied to the substrate underside 21 in a known manner above the tank 13, then the substrate top sides 22 are still covered with the protective film 29 and thus protected from the etching solution 15 having an effect. In order to prevent the situation in which regions of the substrate

top side 22 are exposed or a protective film 29 is no longer present here, for example because the water 27 has run away or partly evaporated as a result of the high temperature during etching, water 27 can be applied again by means of a further application nozzle 26'. Firstly, this additional application nozzle 26' can be designed like the application nozzle 26 upstream of the tank 13, that is to say can produce a rather two-dimensionally distributed, relatively fine spray mist or cover an area region of the substrate top side 22.

If the application nozzle 26' is arranged, however, such that, during the etching method to be carried out, the protective film 29 possibly already becomes thin in places but is still present, then it suffices for water 27 to be resupplied in any form at all. It is thus possible to prevent a situation in which the protective film 29 as it were becomes too thin or is omitted in places. The advantage of such a punctiform application of water 27 to the substrate top side 22 in accordance with a second possibility is that it is not necessary to effect spraying, because during such spraying some of the water 27 inevitably runs past the substrate 20 into the tank 13. Dripping down at the outer edges of the substrate 20 cannot be prevented, however. Since only a very small quantity can drip down or the dripping-down of only very small quantities cannot be avoided, however, as a result hardly any dilution of the etching solution 15 will take place and, consequently, the etching effect will scarcely be impaired. Primarily if the etching solution 15 is applied on to the spray pipe 17 together with spray nozzle 18, it can be supplied in such a way that it is not diluted by water 27.

The enlarged illustration in Figure 2 firstly reveals how the etching solution 15 is applied to the substrate

underside 21 by means of the left-hand transport roller 24 in accordance with DE 10 2005 062 528 A1. As a result, a kind of layer comprising etching solution 15 is formed on the substrate underside 21, which brings about the etching process there. A spray pipe 17 with a spray nozzle 18 is illustrated on the right, said spray nozzle spraying etching solution 15 onto the substrate underside 21. In this case, the illustration shows on the right how some of the sprayed etching solution 15 is sprayed past the substrate 20 and can possibly fall onto a substrate top side 22 of an adjacent substrate moving or arranged alongside on the right. However, the protective film of water present on said substrate can prevent adverse impairment.

Furthermore, the illustration shows how some water 27 drips down from the substrate 20 on the left and right thereof. This water 27 passes into the etching solution 15 in the tank 13 and dilutes said etching solution somewhat. However, since the quantity of water may be very small, particularly in relation to the quantity of etching solution, this circumstance is virtually negligible or can be taken into account accordingly when the mixture of the etching solution 15 is prepared.

Furthermore, it can be seen from Figure 2 that even an application of a relatively large amount of water 27 as a protective film 29 to the substrate top side 22 need not necessarily be harmful, since the etching solution 15 applied to the substrate underside 21 is not necessarily mixed directly with said water 27.

Possibly here the edge areas of the substrate 20 are without a protective film 29 or, if water 27 does not actually overflow over them and cover them, they are not protected. At the edges, however, the effect or damage caused by the etching solution 15 is very small

or negligible, and so said edge areas do not have to be protected.

Instead of water it is possible to use some other liquid for the protective film, for example PEG or polyethylene glycol. The latter is chemically inert and neither reacts with the substrate 20 in an undesired manner nor impairs the effect of the etching solution 15. It is also possible to apply phosphoric acid as protective liquid, which does not adversely impair a substrate such as, for example, a silicon wafer for solar cells. Its higher viscosity is good primarily for the case where the substrates have the above-described perforations or pierced holes.

The exact design of the application nozzles and/or surge pipes, in particular whether and how many thereof are arranged above the tank 13 with etching solution 15, and also the exact local arrangement thereof, can be adapted to the respective etching process or treatment step. For this purpose, by way of example, it is also possible to provide movable application nozzles and/or surge pipes or use is made in each case of just a few of a large number structurally provided in principle.

A top view on an alternative apparatus 111 is illustrated in figure 3. Upstream of a tank 113 with edging solution 115 in it four rows of substrates 120 are running on a continuous passage path composed of transport rollers similar to the ones of figure 1, which are not illustrated here. There can also be less or more rows, for example six rows. Upstream of tank 113, a nozzle pipe 125 is running transverse to the continuous passage path and comprises four application nozzles 126. These are provided in each case with a magnet valve and nozzle openings, which are known to a person skilled in the art and need not be illustrated

further. The width of the application nozzles 126 is less than the width of a substrate 120. The distance of the application nozzles 126 to each other is the same, but need not be.

The nozzle pipe 125 is connected to a supply tank 128 in fluid-conducting manner, in which water 127 for application onto the substrate top sides 122 is provided. By arranging the supply tank 128 at a height level above the application nozzles 126, water 127 flows automatically or on its own accord, respectively, out of it, and by opening or closing the magnet valves of application nozzles 126 the flow of water changes or the volume of water stays the same, respectively. Namely, fluctuations in pressure can be avoided, especially if the magnet valves of the application nozzles 126 are actuated with an offset to each other.

Furthermore, substrate sensors 131 are provided, which are mounted as an example in this case to the nozzle pipe 125, but can also be supported separate from it. The substrate sensors 131 detect the arrival, passing through and passing by of the substrates 120. They can be optical sensors for example, in particular also as light barrier, which detect the nearing of a front edge of a substrate 120 as well as the case that a back edge has passed by. A non-illustrated control device of apparatus 111 receives the signals of the substrate sensors 131 and can then activate the application nozzles 126 or their valves, respectively, in such a way that an application of water 127 onto the substrate top sides 122 only takes place if these are positioned beneath them. This ensures that the water 127 is actually only applied to the substrate top side 122. This is for the purpose that in this case the amount of water can be limited in a way that the two-dimensionally distributed protective film 129 is formed, but water does not flow over the lateral edges

and drools down. On the one hand, the etching solution 115 in consequence is not mixed over the tank 113 with or diluted by water. On the other hand, the etching solution 115 can also act on the lateral edges of the substrate 120 as they are free. Because of the surface tension of the water the cushion or the layer of water 127, which is also illustrated in figures 1 and 2, can form. Possibly also a substrate 120 with a hydrophilic substrate top side 122 can be used, which serves for even enhancing this effect. However, water 127 is applied onto the substrate top sides 122 only once.

In an alternative embodiment of the invention, which can easily be figured, the substrate sensors 131 are dispensed with and a control device of apparatus 111 can calculate from data of a delivery device for substrates connected upstream when these substrates will be positioned exactly underneath the application nozzles 126. In this way a precise and exactly targeted application of water 127 onto the substrate top sides 122 can also take place. Furthermore, significantly more application nozzles 126 and substrate sensors 131 can be provided neighbouring each other, which allow the water to be applied onto the substrate top sides also in the case of differently positioned substrates in an exact way by means of the application nozzle being most centrally positioned above them.

Patent Claims

1. Method for treating a substrate surface of a flat substrate with a process medium at the substrate underside wherein the process medium has a removing or etching effect on the substrate surface, and wherein the substrates are wetted with the process medium from below in a manner lying horizontally, characterized in that the upwardly facing substrate top side is wetted or covered with water or a corresponding protective liquid over a large area or over the whole area as protection against the process medium or the outgassings thereof acting on or reaching the substrate top side.

2. Method according to Claim 1, characterized in that the protective liquid is applied to the substrate top side before the substrate or the substrate underside is wetted with the process medium, in particular before the substrate is moved over a tank with the process medium therein.

3. Method according to Claim 1 or 2, characterized in that the protective liquid is applied to the moved substrates or substrate top sides in a continuous method, preferably by stationary application devices or spray nozzles or surge pipes.

4. Method according to one of the preceding claims, characterized in that the protective liquid is

applied multiply, in particular with time intervals inbetween, to the substrate top side, or is renewed, in particular also while the substrate is situated above the tank with the process medium therein.

5. Method according to one of the claims 1 to 3, characterized in that the protective liquid is applied to the substrate top side one single time, in particular before the substrate is situated above the tank with the process medium therein.

6. Method according to one of the preceding claims, characterized in that the protective liquid is applied to the substrate top side controlled in such a manner that it is applied exclusively to the substrate top side by starting of the application only when a substrate is situated under the application device, and by stopping when the substrate is still situated under the application device, wherein preferably the position or adjustment of an adducted substrate is detected and the application device is controlled depending on this.

7. Method according to one of the preceding claims, characterized in that the protective liquid is applied to the substrate top side with a two-dimensionally distributed profile, in particular by means of spray nozzles designed for producing a two-dimensionally distributed spray mist.

8. Method according to one of the claims 1 to 6, characterized in that the protective liquid is applied to the substrate top side in a punctiform fashion, for the purpose of subsequent flowing, in order to cover the substrate surface over a large area or over the whole area.

9. Method according to one of the preceding claims, characterized in that when the substrate underside is wetted with the process medium, an exothermic reaction takes place with a temperature increase of at least 10°C and a relatively thick layer of protective liquid is applied to the substrate top side, preferably with a thickness of approximately 1 mm or more.

10. Method according to one of the claims 1 to 8, characterized in that when the substrate underside is wetted with the process medium, no significant temperature increase takes place and the thickness of the layer of protective liquid on the substrate top side is relatively small, preferably approximately 50 µm to 200 µm.

11. Method according to one of the preceding claims, characterized in that the substrate underside touches a liquid level of process medium in a tank with the process medium therein, without deeper immersion of the substrates.

12. Method according to one of the preceding claims, characterized in that the substrates are rinsed

after the treatment with the process medium, wherein the protective liquid is also rinsed or removed from the substrate top side.

13. Method according to one of the preceding claims, characterized in that the protective liquid has a higher viscosity than water, and in particular is PEG or phosphoric acid.

14. Method according to one of the preceding claims, characterized in that substrates are treated which are pierced or have perforations, wherein preferably a protective liquid according to Claim 13 having a higher viscosity than water is used.

15. Method according to one of the preceding claims, characterized in that several application devices are arranged one next to the other in a direction approximately transverse to the continuous-passage path of the substrates and the substrates are brought in rows one after the other onto the continuous-passage path and, in each case, continue exactly beneath one application device.

16. Device for carrying out the method according to one of the preceding claims, characterized in that, above a continuous-passage path for substrates which are transported for the treatment of the substrate underside with a process medium over a tank with the process medium therein, at least one application device is provided for

applying water or protective liquid to the upwardly facing substrate top side.

17. Device according to Claim 16, characterized in that the application devices are arranged upstream of the tank with the process medium therein, preferably exclusively upstream.

18. Device according to Claim 16 or 17, characterized in that at least one application device is arranged above the tank with the process medium therein, preferably a further application device upstream of the tank.

19. Device according to Claim 16 or 17, characterized in that at least one application device is arranged upstream of the tank with the process medium therein, wherein preferably one single row of application devices is provided transverse to the continuous-passage path of the substrates with application devices being distanced one from each other, wherein in particular their distance is at least one width of a substrate, wherein the application devices are connected to a supply tank, which is situated higher than the application devices.

20. Device according to one of the claims 16 to 19, characterized in that, seen along the continuous-passage path of the substrates, substrate sensors are provided upstream of the application devices for detection of a substrate being moved closer as

well as for detection of a substrate moved in passing by, in particular optical substrate sensors.