# Method and Device for Treating of a Substrate Surface

Specification

The invention relates to a method and a device for treating of a substrate surface.

In the semiconductor industry countless chemicals are used for processing of semiconductor substrates. Many of the chemicals have components which remain permanently on or in the substrate, other chemicals in turn are removed again from the surface of the substrate after use. One of the best known material classes which must be removed again after use is the photoresist.

Photoresists are used mainly for producing a surface mask. The resist is first applied to the surface of a substrate by a coating process. The most common types of application are spin resist coating and spray resist coating. The thickness of the resist layer is generally in the micrometer range. After application of the resist layer, very often a heat treatment step is carried out which allows the solvent to evaporate and leaves the clean, partially cured resist on the surface of the substrate. After this heat treatment step the resist can be exposed.

The removal of layers (cleaning), especially resist layers, takes place in special process units which can be roughly divided into two groups.

The first group of process units comprises so-called batch process units. In one batch process unit several wafers are fixed on a holding device and dipped into a bath. The bath consists of a chemical which is used for the process of stripping the coating. The batch process unit can be designed to be either hydrostatic or hydrodynamic. In the first version it is a batch with a standing, therefore noncirculating liquid. The advantage of this embodiment consists in that only very small amounts of chemicals are needed. The major disadvantage is the fouling of the chemical by the detached layer. In the course of the cleaning process the concentration of the components of the layer rises. Thus the cleaning efficiency drops at the same time. Furthermore the deposition rate of the layer components which have not been removed on the already cleaned wafers rises so that on average complete, high-purity surface cleaning of the substrates rarely takes place. The chemical

can be changed after a certain number of processed wafers, the walls of the container in which the chemical is located however mostly remain contaminated. In the hydrodynamic version the chemical is continuously renewed and the layer components which have been stripped from the surface of the substrate are removed before re-contamination of the substrate surfaces or the walls of the container takes place at all. Batch process units therefore generally require large amounts of chemicals and therefore cause correspondingly high chemical costs. Furthermore the environment is unnecessarily burdened by large amounts of chemicals.

The second group of process units comprises so-called individual substrate process units which can also be called individual wafer process units when wafers are used. This type of unit allows only serial processing of substrates. At the start of the cleaning process, the chemical is applied to the layer, especially the resist, which is to be stripped or cleaned. The chemical remains for a certain time on the surface of the substrate, dissolves the layer and is afterwards removed in a controlled manner. The removal takes place preferably by spinning it off. The substrate is therefore preferably fixed on a substrate holder of a spin resist coater. The chemical is applied via spray nozzles or hoses.

Individual substrate process units heat the chemicals in exactly the same manner as batch process units. The temperature regulation of the chemicals is necessary to start and/or drive and/or accelerate a chemical reaction with the layer which is to be removed. The heat-up and/or cool-down rates, in exactly the same manner as the heating times and heating temperatures, are generally dependent on all the materials participating in the process, therefore on the layer and/or the chemical.

Individual substrate process units have several decisive advantages over batch process units. They consume many fewer chemicals, can remove the contaminated chemicals very easily from the system, require less energy supply since only a smaller amount of chemicals need be heated, and are thus generally for the most part cheaper, although the throughput of the wafers per unit of time is generally less. Furthermore it has been shown that the yield of correctly processed

wafers in individual substrate process units is generally better than in batch process units.

Although the individual substrate process units therefore constitute a genuine alternative to batch process units, the controllable, exact and reproducible temperature regulation of the chemical constitutes a technical problem. In a batch process unit it is conversely very simple to produce a uniform temperature which can be adjusted and reproduced in a controlled manner since the chemical bath is large compared to the substrates which are to be treated.

In the individual substrate process units the small amount of the chemical which covers the surface of a substrate which is to be cleaned is sufficient to cause dissolution of the layer from the surface, but is not large enough to act as a heat buffer in the sense of statistical physics and thermodynamics. Furthermore the chemical in individual substrate process units wets only one side of the substrate, while the substrate in batch process units is completely surrounded by liquid and thus the substrate is optimally heated through.

But it has been shown in recent years that the constant maintenance of the temperature is of decisive importance for an efficient, complete, economical and reproducible cleaning process. It is not sufficient to heat the chemical above a certain critical temperature. The process window in which optimum cleaning takes place is very narrow and must be precisely maintained.

One technical problem consists in the heating which is generally one-sided so that there is a heat gradient which greatly influences the temperature of the liquid, especially the cleaning liquid.

Embodiments of this invention provide a method which is referenced especially to individual substrate process units and a device for treatment, especially cleaning of a substrate surface which is coated with a resist, in which the cleaning takes place more favorably and more promptly, especially also in a more environmentally-friendly manner.

According to a first aspect of the present invention, there is provided a method for treatment of a substrate surface of a substrate by applying a liquid to the substrate surface or to a layer which is present on the substrate surface, the liquid which has been applied to the substrate surface being heated by a heating area which is located above and/or below the substrate surface, ~~characterized in~~

~~that~~ wherein the temperature $T_R$ of the liquid is kept constant by moving the heating area up and down, wherein the substrate (10) forms the bottom for the added liquid (19) and a border of a substrate holder (4) prevents the liquid (19) from running off, and wherein the border with the substrate (10) lying on the substrate holder (4) forms a trough for accommodating the liquid (19) during the treatment.

According to a second aspect of the present invention, there is provided a device for treatment of a substrate surface of a substrate by applying a liquid to the substrate surface or to a layer which is present on the substrate surface, with the following: a heating area which is located above and/or below the substrate surface for heating of the liquid which has been applied to the substrate surface, means for moving the heating area up and down and keeping the temperature $T_R$ of the liquid constant, wherein the substrate (10) forms the bottom for the added liquid (19) and a border of a substrate holder (4) prevents the liquid (19) from running off, and wherein the border with the substrate (10) lying on the substrate holder (4) forms a trough for accommodating the liquid (19) during the treatment.

All combinations of at least two of the features given in the specification, the claims and/or the figures also fall within the scope of the invention. At the given value ranges, values within the indicated limits will also be considered to be disclosed as boundary values and will be claimed in any combination.

Embodiments of the invention describe a device and a method for keeping a liquid, preferably a chemical for treatment, especially cleaning of a surface, at a temperature as constant as possible and preferably at the same time for ensuring a temperature distribution which is as uniform as possible. Although an embodiment of the invention is used preferably for cleaning processes, it can be used for all processes in which a liquid must be kept at a constant temperature. Conceivable processes would be the following:

- cleaning of a surface
- temperature treatment of a temporary cement, preferably for evaporating the solvent

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~~Amended Claims~~

CLAIMS

1. A method for treatment of a substrate surface (10s) of a substrate (10) by applying a liquid (19) to the substrate surface (10s) or to a layer (17) which is present on the substrate surface (10s), the liquid (19) which has been applied to the substrate surface (10s) being heated by a heating area (6u, 6u', 6u", 6u"', $6u^{IV}$, $6u^{V}$) which is located above and/or below the substrate surface (10s), ~~characterized in that~~

wherein the temperature $T_R$ of the liquid (19) is kept constant by moving the heating area (6u, 6u', 6u", 6u"', $6u^{IV}$, $6u^{V}$) up and down,

wherein the substrate (10) forms the bottom for the added liquid (19) and a border of a substrate holder (4) prevents the liquid (19) from running off, and

wherein the border with the substrate (10) lying on the substrate holder (4) forms a trough for accommodating the liquid (19) during the treatment.

2. The method as claimed in Claim 1, wherein the heating area temperature $T_H$ of the heating area (6u, 6u', 6u", 6u"', $6u^{IV}$, $6u^{V}$) is kept constant at least during treatment, especially in addition during a changing of the substrate (10) which is to be cleaned and/or during a preheating phase.

3. The method as claimed in one of Claims 1 or 2, wherein the heating area (6u, 6u', 6u", 6u"', $6u^{IV}$, $6u^{V}$) is located parallel to the substrate surface (10s) during the treatment.

4. The method as claimed in at least one of the preceding claims, wherein the substrate (10) with its back (10r) which faces away from the substrate surface (10s) is held by an especially rotatable substrate holder (4).

5. The method as claimed in at least one of the preceding claims, wherein the heating area (6u, 6u', 6u", 6u"', $6u^{IV}$, $6u^{V}$) has a minimum distance of 1 mm, especially 10 mm, preferably 25 mm, still more preferably 50 mm, still more preferably 100 mm.

6. The method as claimed in at least one of the preceding claims, wherein the temperature $T_R$ is kept constant, especially solely by control/adjustment of the movement of the heating area (6u, 6u', 6u", 6u"', $6u^{IV}$, $6u^{V}$) up and down, especially with a deviation from the temperature $T_R$ of less than 5°C, preferably less than 1°C, still more preferably less than 0.1°C, still more preferably less than 0.001°C.

7. The method as claimed in at least one of the preceding claims, wherein the temperature $T_R$ and/or the heating area temperature $T_H$ is measured at least during treatment, especially by at least one temperature sensor (15) which is attached preferably to the heating area (6u, 6u', 6u", 6u"', $6u^{IV}$, $6u^{V}$).

8. A device for treatment of a substrate surface (10s) of a substrate (10) by applying a liquid (19) to the substrate surface (10s) or to a layer (17) which is present on the substrate surface (10s), with the following:

- a heating area (6u, 6u', 6u", 6u"', $6u^{IV}$, $6u^{V}$) which is located above and/or below the substrate surface (10s) for heating of the liquid (19) which has been applied to the substrate surface (10s),

- means for moving the heating area (6u, 6u', 6u", 6u"', $6u^{IV}$, $6u^{V}$) up and down and keeping the temperature $T_R$ of the liquid (19) constant,

wherein the substrate (10) forms the bottom for the added liquid (19) and a border of a substrate holder (4) prevents the liquid (19) from running off, and

wherein the border with the substrate (10) lying on the substrate holder (4) forms a trough for accommodating the liquid (19) during the treatment.

9. The device as claimed in Claim 8 with an especially rotatable substrate holder (4) for holding the substrate (10) with its back (10r) facing away from the substrate surface (10s).

10. The device as claimed in Claim 8 or 9 with at least one temperature sensor, which is preferably attached to the heating area (6u, 6u', 6u", 6u"', $6u^{IV}$, $6u^{V}$) for measuring the temperature $T_R$ and/or the heating area temperature $T_H$.