Description

Title of Invention: METHOD FOR DRYING A SEMI-CONDUCTOR WAFER

Technical Field

[0001] The invention refers to a method for drying a surface of a disc-shaped article. More specifically the invention refers to a method for drying by rinsing with an aqueous rinsing-liquid with subsequent rinsing with an organic solvent.

Background Art

[0002] Drying a Methods for drying a surface of a disc-shaped article are typically used in semiconductor industry for cleaning silicon wafer during production processes (e.g. pre photo clean, post CMP-cleaning, and post plasma cleaning). However, such a drying method may be applied for other plate-like articles such as compact discs, photo masks, reticles, magnetic discs or flat panel displays. When used in semiconductor industry it may also be applied for glass substrates (e.g. in silicon-on-insulator processes), III-V substrates (e.g. GaAs) or any other substrate or carrier used for producing integrated circuits.

[0003] Several drying methods are known in semiconductor industry. Many drying methods use a defined liquid/gas boundary layer. Such drying methods are better known as Marangoni drying methods.

[0004] US5,882,433 discloses a combined Marangoni spin drying method. Thereby deionised water is dispensed onto a wafer and simultaneously a mixture of nitrogen with 2-propanol is dispensed. The 2-propanol in the nitrogen shall influence the liquid/ gas boundary layer in that a surface gradient shall occur, which leads to the effect that the water runs of the wafer without leaving any droplets on the wafer (Marangoni Effect). The gas dispenser directly follows the liquid dispenser while the liquid dispenser is moved from the centre to the edge of the wafer and while the wafer is spun and thereby gas directly displaces the liquid from the wafer. Alternatively US5,882,433 discloses a method where an aqueous solution is removed by an organic solution.

[0005] The latter has the problem that an increase of defects occurred when drying a wafer. However, the increase of watermarks did not always occur but the negative effect increased when switching from 200 mm technology to 300 mm.

[0006] It is therefore an object of the invention to avoid the occurrence of watermarks when drying and simultaneously making the drying process easier to control.

Disclosure of Invention

[0007] The invention solves the problems by providing a method for drying a plate-like article. The method comprises rinsing with an aqueous rinsing-liquid with subsequent rinsing with an organic solvent (in liquid form),

[0008] - wherein the organic solvent has a water content of not more than 20 mass-%

[0009] - wherein the organic solvent is supplied at a solvent temperature, which is at least 30°C and a not higher than 60°C.

[0010] The aqueous solution preferably is DI-water (de-ionised water) but can also be a diluted solution of ozone, hydrofluoric acid, hydrochloric acid, carbonic acid, or ammonia.

[0011] Subsequent rinsing means that the start of rinsing with the organic solvent is after the start of rinsing with the aqueous solution. This means that the both rinsing steps can be carried out immediately one after the other, or there can be a time-break between the two rinsing steps. The both rinsing steps can even timely overlap.

[0012] Preferably the organic solvent is miscible with water. The term miscible with water shall be understood that water can be dissolved in the solvent at a water-content of 0 to at least 10 mass-% (even more preferably below 2 mass-%).

[0013] In a preferred embodiment of the method the relative humidity is measured and the dew point is calculated from the relative humidity (e.g. by using Mollier-diagram) and the temperature, at which the organic solvent shall be supplied to the plate-like article, is selected in a range between 20K and 35K above the calculated dew point.

[0014] Without being bound to a theory it is believed that using an organic solvent for removing an aqueous rinsing solution results in cooling the surface of the plate-like article because of fast evaporation of the organic solvent. It is further assumed that the plate-like article thus is cooled below the dew point of the ambient air, which might lead to condensation of the moisture. Therefore water-droplets deriving from the moisture might generate water-marks.

[0015] By selecting a minimum temperature for the organic solvent when supplied in dependency of the humidity the drying performance could be dramatically improved.

[0016] Tab. 1 shows selected preferred ranges of the supply temperature of the organic solvent solution as a function of the dew point, which can be calculated from the measured relative humidity. In the first column the relative humidity of ambient air at 25°C is listed, which equals the relative humidity of 20°C, which is listed in brackets ( ).

[Table 0001]

Table 1

relative humidity at 25°C [%] (equals the relative humidity at 20°C)	dew point [°C] as can be seen in Mollier-diagram	Preferred range of supply temperature [°C]
19 (26)	0.0	20.0 – 35.0
30 (40)	6.0	26.0 – 41.0
40 (55)	10.5	30.5 – 45.5
60 (80)	16.7	36.7 – 51.7

[0017] Advantageously the organic solvent is selected from the group of alcohol (e.g. methanol, ethanol, 2-propanol), ketones (e.g. acetone), ester, ether. These solvents (especially 2-propanol) are well known in semiconductor industry, but other solvents such as hydro fluoro ethers can also be used.

[0018] Preferably the solvent temperature is at least 35°C, which gives an option that a higher humidity can be tolerated.

[0019] In a preferred embodiment the solvent temperature is not more than 55°C, which is preferred because of safety reasons if the organic solvent is flammable.

[0020] Advantageously the organic solvent has a water content of below 10 mass-%. This leaves a basically water-free surface, when the solvent residues evaporate.

[0021] This effect is even improved when the water content of below 5 mass-% or even below 2 mass-%.

[0022] Advantageously the plate-like article is rotated during rinsing with the organic solvent, but can also be linearly moved.

[0023] Advantageously the organic solvent is supplied at a volume flow in a range of 20 ml/min to 400 ml/min. Preferably the flow of the organic solvent is not more than 200ml/min. Such a low flow of the organic solvent only became possible when using the organic solvent at an elevated temperature.

[0024] If the temperature of the dispensed organic solvent is kept at least 25K above the dew point the flow of the organic solvent can be selected below 100ml/min without generating watermarks. This is not only environmentally desired but also helps to keep the drying costs low.

[0025] In another embodiment a fluorine containing solution (e.g. containing hydrogen fluoride, ammonium fluoride) is dispensed onto the disc-like article before the drying is conducted. Preferably such fluorine containing solution is diluted hydrogen fluoride, which is an aqueous solution with an analytical concentration of hydrogen fluoride of

below 1 g/l.

Mode(s) for Carrying Out the Invention

[0026] A preferred method is carried out as follows:

[0027] After a 300 mm semiconductor wafer (a plate-like article) has been placed onto a spin-chuck and the wafer has been gripped by the gripping pins of the spin-chuck a wet process is carried out wherein different liquids are subsequently dispensed onto the wafer. When dispensing the liquids the dispensing nozzle can be moved across the wafer at a selected speed from the centre towards the edge and back to centre. This movement can be repeated as long as the respective liquid is dispensed. The spin speed during dispensing the cleaning liquids is selected in a range of preferably 300 rpm and 2000 rpm.

[0028] First diluted hydrofluoric acid with an HF concentration of 0.01 g/l is dispensed, second a rinsing liquid (e.g. de-ionized water) is dispensed, third the rinsing liquid is turned off and simultaneously the organic solvent supply is turned on, fourth the organic solvent and nitrogen are dispensed simultaneously, and fifth a spin off step.

[0029] The media arm used for this process comprises a nozzle head, which comprises three nozzles. There is a nozzle to dispense diluted hydrogen fluoride or de-ionized water, a nozzle to dispense the organic solvent (the organic solvent here is 2-propanol) and a nozzle for supplying nitrogen. Such a nozzle head and the media arm associated therewith is further described e.g. in WO2008/041211A2.

[0030] The sequence for the drying method is carried out in the following order:

[0031] Step A: As a last chemical dispensing step diluted hydrogen fluoride (concentration between 1g/l to 100 g/l) is dispensed in the wafer centre for a time between 30s to 200s, with a flow rate of 1.7-2 l/min while the wafer is rotating at a spin-speed in a range of 500-1200rpm (e.g. 800rpm). The temperature of the medium is 22°C.

[0032] Step B: The rinsing step (de-ionized water) is also dispensed in the wafer centre for a time of 20s, with a flow rate of 1.7-2 l/min while the wafer is rotating at a spin-speed in a range of 500-1200rpm (e.g. 800rpm). The temperature of the medium is 22°C.

[0033] Step C: The drying step: A nozzle-head scans the wafer once from the centre to the edge at an average speed of 10 mm/s, where at the centre the scanning speed is 20 mm/s and the scanning speed is decrease when moving towards the edge to 5 mm/s. During the scan, 2-propanol is dispensed from the centre till the edge of the wafer. Simultaneously nitrogen is blowing as 2-propanol is supplied. 2-propanol is switched off at the edge of the wafer. 2-propanol has a temperature of 45°C. The 2-propanol is heated with a heat exchanger. The temperature is measured at a distance of 5cm before the nozzle head. The 2-propanol flow is preferably set between 50ml/min to 160ml/min. The cross-sectional area of the nozzle orifice is 8mm² (deriving from a 1/8 inch tube).

Therefore the flow velocity is in a range of between 0.1m/s and 0.33m/s. The warm 2-propanol increases the wafer temperature, which dramatically decreases the number of watermarks – it is believed that this is due to a decrease of condensation because the temperature wafer surface can so be kept above the dew point of the ambient air. Nitrogen flow is increased during the movement of the nozzle-head from the centre to the edge (from 50% to 100% of the maximum nitrogen flow). At maximum (near the edge), the nitrogen flow is around 30 l/min. The chuck speed is reduced linearly from 1100rpm to 450rpm, while the organic-solvent-dispense-nozzle moves from the centre towards the edge of the disc-like article. If the temperature of the dispensed 2-propanol is kept at (or above) 45° the flow of the 2-propanol can be selected below 100ml/min without generating watermarks, which can significantly reduce the consumption of 2-propanol.

[0034] Step D: The final step is a rotation without any chemical dispense for 10s with a rotated spin speed of 1500 rpm. Although this step is not necessary it avoids any back splashing of liquid droplets, which might adhere on the wafer backside and/or on the chuck that rotates the wafer.

Claims

[Claim 0001] Method for drying a plate-like article; the method comprising rinsing with an aqueous rinsing liquid with subsequent rinsing with an organic solvent,
- wherein the organic solvent has a water content of below 20 mass-%
- wherein the organic solvent is supplied at a solvent temperature, which is at least 30°C and not higher than 60°C.

[Claim 0002] Method according to claim 1 wherein the relative humidity is measured and the dew point is calculated from the relative humidity and the temperature, at which the organic solvent shall be supplied to the plate-like article, is selected in a range between 20K and 35K above the calculated dew point.

[Claim 0003] Method according to claim 1 wherein the organic solvent is miscible with water

[Claim 0004] Method according to claim 3 wherein the organic solvent is selected from the group of alcohol (e.g. methanol, ethanol, 2-propanol), ketones (e.g. acetone), ester, ether.

[Claim 0005] Method according to claim 1 wherein the solvent temperature is at least 35°C.

[Claim 0006] Method according to claim 1 wherein the solvent temperature is not more than 55°C.

[Claim 0007] Method according to claim 3 wherein the organic solvent has a water content of below 10 mass-%.

[Claim 0008] Method according to claim 1 wherein the plate-like article is rotated during rinsing with the organic solvent.

[Claim 0009] Method according to claim 1 wherein the organic solvent is supplied at a volume flow in a range of 20 ml/min to 400 ml/min

[Claim 0010] Method according to claim 10 wherein the temperature of the dispensed organic solvent is kept at least 25K above the dew point and the flow of the organic solvent is selected below 100ml/min without generating watermarks

[Claim 0011] Method according to claim 1 wherein a fluorine containing solution is dispensed onto the disc-like article before the drying is conducted.

[Claim 0012] Method according to claim 11 wherein the fluorine containing solution is an aqueous solution that contains hydrogen fluoride at a concentration of below 1g/l.