159159

G00002

Cleaning Process and Apparatus

Field of the Invention

The present invention relates to a cleaning system and method for cleaning substrates, including but not limited to disc-shaped substrates of varying materials, such as to glass, aluminium and silicon.

Background of the Invention

The computer, electronics and entertainment industries use many disc-shaped substrates for the manufacture of electronic circuits. These substrates typically comprise silicon wafers, aluminium, plastics, glass, ceramic and composite materials. For convenience, the materials referred to in this specification will discuss aluminium or glass. This is not to be construed, however, as a limitation on the application of the invention.

The substrates undergo numerous processes in manufacturing, including repeated application and removal of conductive, non-conductive and semi-conductive materials of magnetic, optical and magneto-optical materials.

During manufacturing, the substrates must be buffed, polished, etched and cleaned repeatedly. As the trend in substrate design inclines towards miniaturisation, the level of cleanliness required during the manufacturing process of substrates also increases. In particular, complicated multi-layer circuits require extremely clean substrates to be fabricated on. Otherwise, defects will arise thereby leading to a decreased yield, an increased production time and an inferior product quality.

A problem arises whilst the discs are in the cleaning tank. In this situation, the discs are held by supports often at two points from beneath with the discs subjected to high frequency waves. In recent times, the use of mega sonic

waves has become more common, i.e. acoustic waves having a frequency typically greater than 700 kHz. These mega sonic waves are transmitted from the base of a tank in which cleaning fluid has immersed the discs with the acoustic waves causing cavitation bubbles intended to remove particles from discs. In this arrangement, the discs are subject to the mega sonic waves and then removed from the tank for the next stage in the process. However, the mega sonic waves emanate from the base of the tank, inevitably, the support upon which the discs are mounted create a shadow on the disc and so preventing the waves acting upon portions of said disc. In the past, when ultra sonic waves were more commonly used, these waves had a longer wave length and the problem of the shadow was less frequent due to the diffraction of the ultra sonic waves around the supports and so diminishing the shadow on the disc. The more common use of mega sonic waves having a shorter wave lengths are less prone to diffraction and therefore, the problem of the supports "shadowing" the discs is more prominent.

A still further problem with the process particularly of the discs within the cleaning tank, is the adhesion of the cleaning fluid to the discs as they are removed from the tank. Discs need to be washed after each coating process and again at the final stage prior to full assembly into a hard disk drive. As the washing process usually involves immersing the discs, together with the supports into a tank of the cleaning fluid, subsequent removal of the discs from the tank lead to adhesion of the fluid to the discs, leading to solvent stains and marks from non uniform drying of the solvent.

In a further stage of the process, discs are dried in an oven before being transferred to an unloading station. The rate of drying of the discs by the oven is dependent on a number of factors, such as, but not limited to:

i) The temperature of the air in the oven;
ii) The rate and means of circulation of air in the oven;
iii) Radiation effects of the oven;

iv) Any additional energy sources applied, and;

v) Air pressure within the oven.

Making adjustments to the oven to beneficially affect the rate of drying would nevertheless involve capital cost, and so whilst speeding the drying rate is economically useful, such cost may not justify the end benefit.

In each case it would be preferable if a different arrangement of the various stages of the process so as to avoid at least one of the identified problems of the prior art.

Summary of the Invention

In a first aspect, the invention provides a method for cleaning an article held by support, the method comprising the steps of applying an acoustic wave to said article and support; rotating said article and support such that an area on the article previously masked by the support is exposed to said acoustic wave.

Accordingly by rotating, and so, shifting the position of the articles, the shadow caused by the supports shifts also and, therefore, permits selective exposure of the previously shadowed portions of the discs, allowing complete cleaning due to exposure to the mega sonic waves.

In a preferred embodiment, the articles may be discs, substrates, wafers or other objects having a flat smooth profile.

In a preferred embodiment, the support may comprise racks for engaging several articles at one time. In a more preferred embodiment, the means of engagement may be through gravity, and further through the articles placed on lugs projecting outwards. Alternatively, the engagement may be through vacuum or mechanical engagement, with the invention applying to those forms

of engagement or supports that involve a portion of said support to form a shadow over a portion of the article.

Preferably the rotation has a center of rotation outside the disc. In this case, rotation may be achieved by a full rotation of the disc and supports. Alternatively the discs may be rotated about its own center such as through the supports acting as rollers so as to rotate the discs within the tank.

In a second aspect, the invention provides a cleaning system for cleaning an article comprising a support upon which the article is located an acoustic wave generator for directing an acoustic wave along a path coincident with said support and article; said support arranged to selectively rotate about a centre of rotation, and consequently rotate said article.

In a third aspect, the invention provides a method for removing an article from a cleaning system, comprising the steps of providing the article engaged by a support and immersed in a tank of cleaning fluid; moving the tank downwards relative to the article so as to move the article from a completely immersed position to a position where at least a portion of the article is no longer immersed; removing the article from the tank.

In a fourth aspect of the present invention provides a cleaning system for cleaning an article comprising a tank containing cleaning liquid; a support for engaging the article within the cleaning liquid; wherein said tank is selectively movable relative to said support in a direction for removing said article from said cleaning liquid.

In a fifth aspect, the invention provides a method of drying an article comprising the steps of placing said article in an oven; dehumidifying a flow of hot air then; directing said hot air flow to said oven.

Factors affecting the drying of an article, such as a disc, within an oven can be addressed by undertaking modification to the oven including adding additional energy sources, increasing air circulation and increasing pressure, for instance. However, a further factor includes reducing the humidity in the oven itself. By pre-drying the flow of hot air into the oven, prior to entry into the oven, the problems associated with drying rates can be circumvented.

In a preferred embodiment, to further reduce humidity, a dehumidifier may also be added to the oven.

Brief description of the drawings

It will be convenient to further describe the present invention with respect to the accompanying drawings that illustrate possible arrangements of the invention. Other arrangements of the invention are possible, and consequently the particularity of the accompanying drawings is not to be understood as superseding the generality of the preceding description of the invention.

Figures 1A to 1E show elevation views of the support and discs according to one embodiment of the present invention; and

Figure 2 shows a sequential elevation view of the cleaning tank according to a further embodiment of the present invention.

Detailed Description of the Preferred Embodiment

Figure 1A shows a detailed view of a support 1305 which is used to engage an article, such as a disc (not shown) whilst in a cleaning tank. The cleaning tank is typically filled with a cleaning fluid such as warm de-ionized water or diluted isopropyl alcohol.

Typically the tank will have a generator of acoustic waves in the base whereby the supports lower the discs into the tank for cleaning and the acoustic wave generator generates waves and subsequently cavitation to remove particles from the discs. Traditionally ultrasonic waves have been used at a frequency around 200 kHz with more recently mega-sonic waves, with a frequency greater than 700 kHz, have started to become more common. A characteristic of the use of mega-sonic waves is that shown in Figure 1A. Because of the high frequency, the wave lengths are shorter and so, the diffraction patterns experienced for ultrasonic cleaning as shown in Figure 1B are less pronounced. The result being that the shadow affect 1325 being of a reduced size for ultrasonic waves as seen in Figure 1B are now replaced by much larger shadow areas 1315 for mega-sonic wave cleaning. These shadows are caused by the onset of the acoustic waves contacting the support 1305 which acts as a shield downstream from said support. Thus, whilst some level of shadow 1325 was known in the traditional ultrasonic cleaning, this problem is enhanced and accordingly is more serious with mega sonic cleaning due to the increase in the size of the shadow 1315.

Figures 1C to 1E demonstrate the solution according to an embodiment of the present invention. In traditional cleaning tanks, the discs are supported by supports having lugs or projections which contact the disc at two points in the lower sector of the disc. Figure 1C shows an arrangement similar to the traditional arrangement whereby the disc 1350 is supported by the support whereby the support may be a pair of lugs 1305 mounted to a larger rack holding several such discs. The discs are lowered into a cleaning tank 1355 and so immersed within the cleaning fluid. As the acoustic waves contact the lugs 1305, a shadow 1345 downstream from the lugs 1305 results in a portion of the disc that remains uncleaned. The solution according to this embodiment of the present invention, is to rotate the disc 1350 about a center of rotation 1340 during the cleaning process. Whilst the shadow effect cannot be removed by shifting the position of the disc 1350, the shadows caused by the lugs 1305 shift to a different portion of the disc, leaving the formerly "shadowed" area of

the disc exposed to the acoustic waves and thus being cleaned. As can be seen in Figure 1D, the disc 1350 has been rotated 1360 about the point of rotation 1340 such that a new shadow area 1365 is created but exposing the previous shadow to the acoustic waves and thus affecting an efficient and complete clean of the disc. To ensure a complete clean within the residence time normally associated with the cleaning process, the support can swing in the opposite direction 1370 and thus creating a further shadow zone 1375 but also exposing both of the two previous shadow areas in order to effect the clean.

The number of oscillations of the discs and the time taken during this oscillation will vary according to the type of cleaning being undertaken and it will be clear to the skilled person how long a residence time in the bath is required in order to completely clean any areas which have been subject to the shadow.

Thus rotation of the disc can avoid the problems associated with the shadow areas. It will be appreciated that the location of the point of rotation may vary according to the nature of the cleaning process and will be a matter of routine experimentation to determine the ideal point of rotation for any particular situation. For instance, the invention also includes having the point of rotation within the area of the disc and, for instance, at the center of the disc such that the disc itself is rotated with the support staying stationary. This could be achieved by having the lugs acting as rollers and so rotating the disc through rotation of the lug/rollers in order to expose the shadowed areas to the acoustic cleaning wave.

Figure 2 shows a cleaning tank 1405 in which an article to be cleaned, in this case a disc 1410, is being immersed within the cleaning fluid and supported by lugs 1415. Traditional means of removal of the article following the cleaning process would involve lifting the article clear of the cleaning fluid. This would, however, result in a significant volume of the cleaning fluid adhering to the article causing stains as the article dries and, further, marks forming from the non uniform drying of the fluid remaining on the article. The solution according

to the present invention involves a number of steps aimed at minimizing the adhesion of the fluid to the article. In the first step, similar to the convention method, the article, in this case a disc 1410, is lifted through raising the lugs 1420 of the support until the disc 1410 is proximate to the surface 1406 of the cleaning fluid 1407. Then the tank 1405 is lowered 1425 rather than the disc being lifted. The electrostatic attraction of the greater volume of fluid within the tank therefore, tends to draw the fluid from the surface of the disc which would not be possible in the reverse situation of lifting the disc from the tank. This principle is known as "dynamic de-wetting". The tank is then lowered until the central orifice 1421 of the disc is clear of the surface of the cleaning tank whereupon the lowering process 1425 is stopped. Finally a projection 1430 is inserted within the orifice 1421 and the disc lifted clear off the supports 1415 so as to clear the disc from the cleaning fluid.

The problem associated with existing methods is enhanced by the central orifice in the disc. The orifice created a disturbance in the surface of the cleaning fluid as the disc is lifted from the cleaning tank in one continuous step. It is observed that a break line across the disc where the cleaning fluid surface contacts the orifice. Thus the solution seeks to reduce this break line by lifting the disc to the level of the orifice and then lowering the entire cleaning tank instead of lifting the disc from the solvent.

A further problem of lifting the disc out of the cleaning surface in one continuous movement is the relative speed with which the solvent flows off the surface of the disc. The surface area remaining on the cleaning fluid still adhering to the disc surface gets smaller and therefore, increases the rate of formation of micro droplets of the cleaning fluid on the disc surface due to different rates of flow of the cleaning fluid of the disc surface. By lowering the entire tank, a significant volume if not all the adhering cleaning fluid, flows off the disc surface and so the risk of micro droplets of the cleaning fluid forming is greatly reduced.

Further still, in order to speed the drying process the solvent is heated so as to increase the rate of vaporization of any remaining solvent on the disc. Typically the temperature of the solvent is raised to between 50°C and 60°C.

5

Claims

1. A method for cleaning an article held by support, the method comprising the steps of:

applying an acoustic wave to said article and support;

rotating said article and support such that an area on the article previously masked by the support is exposed to said acoustic wave.

2. The method according to claim 1 wherein said acoustic wave is a unidirectional mega-sonic or ultrasonic wave.

3. The method according to claims 1 or 2 wherein said support and article are immersed in a liquid.

4. The method according to any one of claims 1 to 3 wherein said support maintains the article in a vertical orientation with said acoustic wave directed upwards towards said article.

5. The method according to any one of claims 1 to 4 wherein said support includes lugs contact a peripheral edge of said article.

6. A cleaning system for cleaning an article comprising

a support upon which the article is located

an acoustic wave generator for directing an acoustic wave along a path coincident with said support and article;

said support arranged to selectively rotate about a centre of rotation, and consequently rotate said article.

7. The cleaning system according to claim 6 wherein the support is arranged to position the article so as to be immersed within a liquid, said acoustic wave generator arranged to generate a wave through said liquid.

8. The cleaning system according to claim 6 or 7 wherein the degree of rotation of said article and support is sufficient to allow the entire article to be exposed to said acoustic wave.

9. The cleaning system according to any one of claims 6 to 8 wherein said acoustic wave generator generates mega-sonic waves.

10. A method for removing an article from a cleaning system, comprising the steps of:

providing the article engaged by a support and immersed in a tank of cleaning fluid;

moving the tank downwards relative to the article so as to move the article from a completely immersed position to a position where at least a portion of the article is no longer immersed;

removing the article from the tank.

11. The method according to claim 10 wherein the portion is greater than 50% of the article.

12. The method according to claim 10, wherein the article includes an orifice and the portion that part of the article such that the orifice is no longer immersed.

13. The method according to any one of claims 10 to 12 further including, prior to the step of moving the tank, the step of moving the support so as to move the article to a position so as to be completely immersed, but contiguous with a surface of the cleaning liquid.

14. The method according to any one of claims 10 to 13 wherein the step of removing the article includes engaging the article with a second support, external to the tank, and lifting said article clear.

15. The method according to claim 14 wherein the step of engaging the article includes the step of inserting a projection into the orifice of the article.

16. A cleaning system for cleaning an article comprising
a tank containing cleaning liquid;
a support for engaging the article within the cleaning liquid;
wherein said tank is selectively movable relative to said support in a direction for removing said article from said cleaning liquid.

17. The cleaning system according to claim 16 wherein support is movable relative to said tank in a direction for removing said article from said cleaning liquid.

18. The cleaning system according to claim 16 or 17, further including a second support for engaging the article when at least a portion of said article projects from the cleaning liquid.

19. The cleaning system according to claim 18 wherein the second support includes a projection arranged to insert within an orifice of said article.

20. The cleaning system according to claim 6 or 16, wherein the article is any one or a combination of: discs, wafers and substrates.

21. The cleaning system according to claim 6 or 16 wherein said support is arranged to engage a plurality of said articles.

22. The method according to claim 1 or 10, wherein the article is any one or a combination of: discs, wafers and substrates.

23. The cleaning system according to claim 1 or 10, wherein said support is arranged to engage a plurality of said articles.

24. A method of drying an article comprising the steps of:
placing said article in an oven;
dehumidifying a flow of hot air then;
directing said hot air flow to said oven.

25. The method according to claim 24 further including the step of dehumidifying air in the oven prior to the step of directing the flow of hot air to the oven.