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APPARATUS AND METHOD FOR IN-LINE INSPECTION OF A WAFER CHUCK

BACKGROUND OF THE INVENTION

(1) FIELD OF THE INVENTION

The invention pertains to the general field of semiconductor integrated circuits, more particularly to the coating and imaging of wafers with photoresist and associated problems.

(2) DESCRIPTION OF THE PRIOR ART

During the processing of integrated circuits, semiconductor wafers are coated with photoresist and then exposed to ultraviolet light many times. The photoresist is applied by dispensing it onto the surface of a spinning wafer, centrifugal force then causing it to spread out evenly over the surface. After the photoresist has been baked on a hot plate, it is exposed to ultraviolet light while being held in position on the exposure system's chuck (see FIG. 1). This is for the purpose of defining in it a precise pattern, a

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process referred to as photolithography. For reasons relating to the efficiency of a production line, the same chuck may be used to hold the wafer both during photoresist application as well as during photolithography.

Since the tolerances involved in photolithography (as applied to integrated circuits) are well under 1 micron, it is imperative that the chuck be kept meticulously clean at all times. Unfortunately, photoresist application is not a particularly clean process so it is necessary, in practice, to check the chuck's surface each time it is to be used for photolithography and, if necessary, remove it for closer inspection and possible cleaning.

Prior to the present invention, our practice had been to inspect the chuck's surface visually and, if in doubt, remove it for closer inspection and possible cleaning. The removal and cleaning of the chuck, though necessary, is time consuming and, therefore, expensive. What was needed was a reliable method of rapidly inspecting the chuck's surface that did not involve its removal from the line. We have been unable to find such an invention described in the prior art.

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SUMMARY OF THE INVENTION

It is an object of the present invention to provide an apparatus that allows the surface of a semiconductor wafer chuck to be inspected for cleanliness without removing it from its position in a production line.

Another object of the invention is to provide a method for using such an apparatus.

Yet another object of the invention is that it enable the inspection to be carried out rapidly but be at least as reliable as off-line methods.

These objects have been achieved by scanning the surface under inspection with a laser beam thereby creating a computer readable image of the surface. A previously created image of the surface, made when it was known to be completely clean, is stored in the computer and is subtracted from the current image prior to displaying it. Thus any departures of the surface from a state of complete cleanliness are readily seen.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the apparatus of the present invention in isometric view.

FIG. 2 is a plan view of a wafer chuck of the grooved type.

FIG. 3 is a cross-section through FIG. 2.

FIG. 4 is a plan view of a wafer chuck of the pin type.

FIG. 5 is a cross-section through FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, we show there a semiconductor wafer chuck 1, mounted on tilt plate 2 which is itself mounted on an X-Y stage. Said stage comprises an X-stage 3 and a Y-stage 4. Positioned above said X-Y stage is a laser beam emission source 5 (such as, but not limited to, helium-neon or helium-cadmium) which emits a continuous, low power laser beam 6. 5 has been directed so that beam 6 strikes a point somewhere on the surface of chuck 1, following which it is reflected away from said surface as beam 8.

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Laser beam detector 7 is positioned so as to receive beam 8, producing an output signal 9 whose value is proportional to the intensity of 8. The relative positions and angular orientations of 5 and 7 are permanently fixed relative to one another. Tilt plate 2 is used to ensure that the plane in which the top surface of the wafer chuck lies is parallel to the plane along which it will be moved by the X-Y stage. Once this condition is met, beam 8 will continue to enter detector 7, without need to change the angles of 5 and 7 relative to 1, even if the location of chuck 1 relative to that of beam source 5 is changed.

X-stage 3 and Y-stage 4 are caused to move, independently, by drivers 13 and 14, respectively. Signals from the stepping motors (not shown) that power 13 and 14 can be used to provide computer readable information as to the exact location of chuck 1 at any time. Additionally, output signal 9, which is proportional to the intensity of the reflected beam 8 can readily be digitized, thereby rendering it computer readable as well.

By means of computer software, the X-Y and reflected beam intensity information can be utilized to move, in a systematic manner, the spot where beam 6 strikes the surface of 1 (so that all points on the surface of 1 are struck by the beam once, and only once), associating with each such point a value for the intensity

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of the reflected beam. This information is readily stored in the computer's memory and, also, is readily displayed on the computer's monitor as a picture of the chuck's surface.

A picture of the type just described can be created in a few minutes without the need to remove the chuck or any of its associated parts. This is particularly important if, for example, the chuck is part of a production line which would be disrupted if the chuck had to be removed for inspection.

The inspection itself can be performed by examining the aforementioned picture. While many defects such as dust particles, wisps of photoresist, etc. would easily be seen in a picture of this sort, slight local irregularities in the surface of the chuck itself might be mistaken for defects. Therefore, as an important feature of the present invention, a picture of the chuck, formed when the chuck is known to be extremely clean (for example when it is brand new) is stored in the computer as a reference picture. When a picture is formed for inspection purposes, values for the reflected beam at the corresponding points in the reference picture are first subtracted (by the computer). In this way, any irregularity seen on the screen is immediately known to represent a departure from a completely clean chuck surface.

In a second embodiment of the invention, the laser beam and

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detection sytem are provided with their own X-Y driving system. During picture formation, the chuck (including its X-Y driving system) is kept stationary while the beam and detector are systematically moved. Since the relative motions involved are the same, picture formation in this embodiment is the same as in the first embodiment. Although the second embodiment would appear to be more expensive than the first, it offers several advantages: it may be difficult, inconvenient, or expensive to modify the X-Y stage that comes with the chuck; and, should it become necessary to remove the chuck's X-Y stage (for repair or for maintenance), a temporary replacement may be used without any interruption of the inspection capability provided by the present invention.

In addition to holding the wafer during the application of photoresist, the chuck is also used during photolithography. Since the tolerances involved in the latter operation are well under 1 micron, it is clear that the semiconductor wafer must be supported by the chuck in a manner that holds it firmly in place without, at the same time, introducing either stress or distortion to the wafer's top surface.

In general, two types of vacuum chuck have been used for holding the semiconductor wafers in place. The first, known as the grooved type, is illustrated, in plan, in FIG. 2. A series of concentric ridges 21 project above the main surface of the chuck 22



and serve to support the wafer. A large number of holes, such as 23, are drilled through surface 22 (which now has the appearance of a series of grooves) and connected to a source of vacuum (not shown). FIG. 3 shows a cross-section view of FIG. 2 made at AA . Not apparent in FIG. 2, but seen in FIG. 3, is shaft 24 used for rotating the chuck. Said shaft can be mounted directly to a spin motor (without the X-Y stage) during resist application. In addition, a cross-section through a semiconductor wafer 25, in place on the chuck, has been added for illustrative purposes.

The second type of chuck, which also employs a vacuum as the securing means, is known as the pin type. It is illustrated, in plan, in FIG. 4. A large number of flat-topped pins such as 41 extend upwards from main surface 43 and serve to support the wafer in a similar manner to the ridges in the grooved type. Holes such as 42 are drilled through 43 and connected to a source of vacuum (not shown). In order to assist in placing the wafer symmetrically over the center of rotation, insertable rims, corresponding to the diameter of the wafer being processed, are also used. For example, rim 44 might be used while 6 inch diameter wafers are being processed while rim 45 might be used during the processing of 8 inch wafers.

FIG. 5 is a cross-section made at BB in FIG. 4. Not apparent in FIG. 4, but seen in FIG. 5, is shaft 46 used for rotating the



chuck. In addition, a cross-section through a semiconductor wafer 47, in place on the chuck, has been added for illustrative purposes.

While the invention has been particularly shown and described with reference to the two preferred embodiments discussed above, it will be understood by those skilled in the art that various changes in form and details may be made without departing from the spirit and scope of the invention. For example, either embodiment could be successfully implemented using either of the chuck designs that have just been described above.

What is claimed is:

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1. An apparatus comprising:
 - a semiconductor wafer chuck having an upper surface;
 - a laser beam emission source, positioned relative to said chuck so as to cause said laser beam to strike said upper surface at an oblique angle and then be reflected;
 - 5 a laser beam detector that provides a first output signal, located in fixed relationship to said laser beam emission source, and directed to receive said reflected beam;
 - means for moving said chuck and said laser beam emission source relative to one another;
 - 10 a second output signal that provides information concerning the location of said source and said chuck relative to one another;
 - means for forming pictures of said upper surface from information contained in said first and second output signals;
 - 15 means for recording and displaying said pictures;
 - means for electronically subtracting one of said pictures from a different one of said pictures; and
 - means for recording and displaying the result of said electronic subtraction.
 - 20
2. The apparatus described in claim 1 wherein said laser beam emission source comprises a helium-neon laser.
3. The apparatus described in claim 1 wherein said laser



beam emission source comprises a helium-cadmium laser.

4. The apparatus described in claim 1 wherein said means for moving said chuck and said laser beam emission source relative to one another comprises a fixed chuck and a moveable
5 laser beam emission source.

5. The apparatus described in claim 1 wherein said means for moving said chuck and said laser beam emission source relative to one another comprises a fixed laser beam emission source and a moveable chuck.

10 6. The apparatus described in claim 1 wherein said upper surface comprises:

concentric trenches, evenly spaced relative to one another; and

holes, connected to a source of vacuum, uniformly
15 distributed in said trenches.

7. The apparatus described in claim 1 wherein said upper surface comprises:

a plurality of pins of uniform height upwardly projecting from said upper surface; and

20 holes, connected to a source of vacuum, uniformly distributed in said upper surface.



8. A method for inspecting the surface of a wafer chuck comprising:

providing a laser beam emission source;

providing a laser beam detector having an output signal;

5 directing said laser beam to strike said surface at an oblique angle, thereby producing a reflected beam;

positioning said beam detector in fixed relationship relative to said laser beam emission source so as receive said reflected beam;

10 electronically processing said output signal together with locational information produced when said laser beam emission source and said chuck are moved relative to one another, thereby forming a picture of said surface; and recording and displaying said picture.

15 9. The method of claim 8 further comprising:

forming and recording a first picture of said surface while said surface is known to be extremely clean;

forming and recording a second picture after said wafer chuck has been used to hold semiconductors wafers while they
20 were coated with photoresist; and

electronically subtracting said second picture from said first picture and displaying the result of said electronic subtraction.



10. The method of claim 8 wherein said laser beam emission source comprises a helium-neon laser.

11. The method of claim 8 wherein said laser beam emission source comprises a helium-cadmium laser.

5 12. The method of claim 8 further comprising:
fixing the position of said laser beam emission source
and moving said chuck.

13. The method of claim 8 further comprising:
fixing the position of said chuck and moving said laser
10 beam emission source.

14. The method of claim 9 wherein said first picture comprises a picture of a wafer chuck that has never been used.

15. The method of claim 9 further comprising:
examining the result of said electronic subtraction; and
15 deciding, based on said examination, whether said chuck
should be taken off line to be cleaned.

16. The method of claim 8 wherein said inspection is performed in-line.



17. The method of claim 9 wherein said inspection is performed in-line.

18. The method of claim 8 wherein said inspection is performed in less than about 10 minutes.

5 19. The method of claim 9 wherein said inspection is performed in less than about 1 minute.