POLISHING PAD HAVING MULTI-WINDOWS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a polishing pad for enabling the polished quantity of a wafer to be measured more rapidly and precisely in Chemical Mechanical Polishing (hereinafter, referred to as 'CMP'). More particularly, the polishing pad of the invention integrally has a polishing section and multi-windows made of the same material as the polishing section in order to enable a precise CMP process and achieve excellent structural endurance.

Description of the Related Art

CMP is one of super precision/mirror face-polishing techniques in use for global planarization in a semiconductor device fabrication process. In particular, during CMP abrasive in the form of slurry is injected between a polishing pad and a wafer to be polished (hereinafter, referred to as 'wafer') in order to chemically corrode the surface of the wafer and then to mechanically polish the corroded surface.

According to development of semiconductor technology, lines are gradually reduced with size up to sub-micrometer lines,

which are introduced lately. In order to introduce the sub-micrometer lines, the surface of a wafer applied with lines is necessarily polished at a coarseness of nm scale. As a result, CMP is required to have a polishing-regulating ability in nm scale. In particular, a CMP process performed without a correct polishing termination leads to over-polishing to excessively polish an insulation layer or under-polishing to incompletely polish the insulation layer, thereby causing defects to a semiconductor device.

In order to remove such process defects which are created during polishing, researches have been made actively to correctly find a polishing termination in the CMP field. United States Patent No.5,893,796, which was devised to correctly find the polishing termination during such researches, discloses a method for detecting the state of wafer during polishing with a laser by inserting a transparent window in a polishing pad.

A Mirra CMP apparatus available from Applied Material in USA detects the polishing termination using United States Patent No.5,893,796. This apparatus, as shown in FIG. 1, is operated as follows: A laser interferometer 50 placed under a polishing pad 10 oscillates a laser beam 60, which is passed through a hole 30 (window portion) and reflects from a wafer 40 above the hole 30 to be detected by a laser sensor arranged in a platen 20. The intensity of the detected laser beam is compared with

that of the initially oscillated laser beam to calculate the thickness of the wafer 40. In this manner, measurement is performed to the thickness of the wafer 40 which rotates about its central axis 80 fixed to a polishing head 70 at every rotation of the platen 20 about its central axis 90 in order to detect the polishing termination based upon the thickness of a residual film.

However, this technique using the window portion formed in the polishing pad has a problem that slurry permeates through a joint around the window portion to weaken the endurance of the pad or to probably cause defects onto the wafer. When polishing lasts for a long time period, the transparent window and the polishing pad are abraded at quantities different from each other to bring thickness ununiformity to the pad. If the pad thickness is ununiform, the wafer is contacted with an uneven face, and thus it is impossible to obtain an evenly polished face in the wafer.

SUMMARY OF THE INVENTION

The present invention proposes to provide multi-windows or a plurality of windows in a CMP polishing pad so that polishing quantity can be adjusted more precisely than in a conventional pad of a single window, by which the measurement period of

residual film thickness with a laser during rotation of a platen is remarkably reduced in order to enable the residual film thickness to be monitored with an improved precision and at a faster period over conventional techniques. According to application of the pad enabling the residual film thickness to be measured at the faster period, a polishing termination is controlled more precisely. As a result, the invention can be applied to polishing termination measurement in future nm scale CMP processes.

Further, in order to solve the foregoing problems of the conventional pad which are created owing to the transparent window inserted into the polishing pad, the present invention integrally forms both the transparent windows in use for polishing termination detection and a polishing section with an equal material. This fundamentally overcomes the problem that abrasive in the form of slurry permeates into a region of the polishing pad in which the transparent window is inserted. Also, the pad is uniformly abraded owing to a conditioner to minimize the thickness variation between the transparent windows and the polishing section.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and other advantages

of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 illustrates a conventional CMP apparatus for detecting a polishing termination;

FIG. 2 is a Scanning Electron Microscopy (SEM) photograph showing the surface of a polishing pad having holes and/or grooves according to the invention; and

FIG. 3 illustrates a polishing pad having a plurality of transparent windows according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The following detailed description will present a preferred embodiment of the invention with reference to the accompanying drawings.

A polishing pad of the invention has an integral structure of a polishing section and a plurality of transparent windows or multi-windows for passage of a laser beam, in which the polishing section and the multi-windows are made of the same material.

The polishing pad is made of a transparent material for substantially passing the laser beam through the same, which is at least one selected from a group including polyurethane,

polyester, PVC, artificial leather and rubber. The polishing pad may have grooves of a width of about 100 to 1,000㎛ or micro-holes of a diameter of about 100 to 250㎛ formed in the surface thereof so that abrasive in the form of slurry may efficiently flow between a wafer and the polishing pad. Such surface treatment is not carried out in predetermined regions of the polishing pad to be formed into transparent windows. Examples of the micro-holes and grooves formed in a polishing section of the polishing pad according to the invention are illustrated in a Scanning Electron Microscopy (SEM) image in FIG. 2.

According to the invention, 2 to 10 transparent windows 3 are preferably formed, with a size of about 2x5cm. As an illustrative example thereof, four transparent windows 3 are formed as shown in FIG. 3, each transparent window being arranged at an interval of 90 degree from adjacent ones, so that the wafer can be observed four times through the four transparent windows at every single rotation of the polishing pad 1 on the CMP apparatus. As a result, when compared with a conventional polishing pad provided with a single transparent window, the invention can reduce the measuring period of a residual film of the wafer to a quarter of that of the conventional polishing pad, so that information can be transferred to a control unit of a CMP process at a rate 4 times faster than in the prior art.

That is, owing to the four transparent windows, the CMP process of the invention can reduce the controlled quantity of polishing to a quarter of that of a conventional polishing process.

Application of the polishing pad having the four transparent windows has the following effects: A wafer is polished for 60Å at every one rotation thereof with a conventional polishing pad under ordinary conditions. Therefore, with the conventional polishing pad of the single transparent window, the CMP process can be monitored and controlled at the minimum scale of 60Å. However, with the polishing pad of the four transparent windows of the invention, the wafer can be monitored at every quarter rotation thereof to reduce the minimum monitoring scale to 15Å, which is a quarter of 60Å given by the conventional polishing pad, thereby enabling the precision of the CMP process to be regulated at the scale of 15Å. The plurality of transparent windows according to the invention can reduce the measurement period of the residual film at a rate inversely proportional to the number of the windows, thereby imparting more precision control to the process.

Variation in the measurement period of the residual film according to the plurality of transparent windows will be expressed as Equation 1 below:

$$f \fallingdotseq 1/\lambda \fallingdotseq n \quad \ldots\ldots \text{Equation 1,}$$

wherein the number n of the transparent windows is inversely proportional to the period λ of measuring the thickness of the residual film through the transparent windows, but proportional to the frequency f of observing the wafer through the transparent windows per a single rotation of a platen.

In the case that n number of the transparent windows are applied, the polished quantity of the wafer is measured at every $1/n$ rotation of the platen, and thus the minimum scale of polishing m will be expressed as Equation 2 below:

$$m = M/n \quad \text{.... Equation 2,}$$

wherein M is the quantity of the wafer polished at every one rotation of the polishing pad.

Because n increases in proportion to the number of the transparent windows in Equation 2 above, the minimum scale of polishing m indicating the quantity of measurement at every $1/n$ rotation is reduced, so that the polished quantity can be measured with a more precise scale according to the increase of n. In a conventional pad having a single transparent window, since n is 1, the minimum scale of polishing m which can be observed at a single measurement is M. If $n = 4$ is given to a polishing pad having a plurality of transparent windows, measurement is performed four times at every rotation of the platen, so that the minimum scale of polishing m becomes $M/4$

which is 25% level of that of the conventional polishing pad, thereby to ensure a precision of four times of that of the conventional polishing pad.

Further, the polishing pad fabricated according to the invention is essentially transparent, with a polishing face formed integral with the transparent windows, so as to fundamentally prevent problems that abrasive or slurry leaks out between the polishing section 2 and the transparent windows 3 unlike the conventional polishing pad in which the transparent window is additionally inserted therein. This can enhance the endurance of the polishing pad of the invention. Since the polishing face of the pad is made of a material same as that of the transparent windows, the entire thickness across the pad can be maintained uniform in the course of CMP.

Prior to forming the micro-holes and/or grooves in the pad to generate the transparent windows, predetermined regions on the polishing pad to be formed into the transparent windows are attached with protective covers having same configuration and size as those of the transparent windows, so that the predetermined window regions of the polishing pad are not processed in the course of micro-hole and/or groove processing in order to form the transparent windows.

Since the plurality of transparent windows are formed integral with and made of the same material as the polishing

section according to the invention, the polishing pad of the invention allows the CMP process to be performed more precisely than in the conventional pad with the single window additionally inserted therein as well as have an structural endurance superior to that of the conventional pad.

Therefore, the polishing pad according to the invention has the following effects:

(1) The polished quantity of the wafer can be measured/controlled more precisely than in the conventional pad of the single window so as to improve the precision of polishing termination measurement, thereby preventing over-polishing or under-polishing of the wafer.

(2) The polishing section and the transparent windows are made of the same material to minimize thickness variation in the polishing pad during the CMP process.

(3) The polishing section and the transparent windows are provided integral to prevent abrasive from leaking into the pad.

What is Claimed is

1. A polishing pad comprising:
a polishing section having a number of grooves and micro-holes formed in the surface thereof for allowing slurry to flow; and
a plurality of transparent windows which are formed integral with and made of the same material as the polishing section and are used for determining polishing termination;
wherein the micro-holes and the grooves are processed on the polishing section after predetermined regions on the transparent polishing pad to form the transparent windows are attached with protective covers having the same configuration and size as those of the transparent windows, so that the transparent window regions of the polishing pad are not processed in the course of the micro-holes and grooves processing in order to form the transparent windows.

2. The polishing pad according to claim 1, wherein the polishing pad has 2 to 10 transparent windows.

3. The polishing pad according to claim 1, wherein the polishing section and the transparent windows are made of at least one material selected from a group including polyurethane, polyester, PVC, artificial leather and rubber.