

Description

HYDROPHOBIC CUTTING TOOL AND METHOD FOR MANUFACTURING THE SAME

Technical Field

- [1] The present invention relates to a cutting tool, and more specifically, to a hydrophobic cutting tool having good high hydrophobicity maintaining performance of a surface thereof and a method for manufacturing the same. In particular, the present invention relates to a CMP conditioner, i.e., cutting tool used in a CMP (Chemical Mechanical Polishing) pad conditioning process (chemical mechanical polishing) and suitable for reducing accumulation of slurry thereon.

Background Art

- [2] A cutting tool is a tool that cuts a workpiece using abrasives, i.e., cutting particles. In the present invention, "cutting" includes grinding such as a cylinder grinding, an inner surface grinding, or a plane grinding to grind a part of a workpiece. For instance, the grinding includes all kinds of machining works capable of being performed using abrasives such as diamond particles.
- [3] In general, a cutting tool comprises a substrate and an abrasive layer formed on a surface of the substrate, and has a structure wherein a plurality of abrasives is bonded to the surface of the abrasive layer. The bonding of the abrasives is performed by various methods including electrodeposition, sintering, and brazing. The abrasives include diamond, CBN (cubic boron nitride), alumina, and silicon carbide particles.
- [4] In a machining work using a cutting tool, a phenomenon that a surface of an abrasive holding layer is contaminated occurs, and the surface is more and more contaminated as the working time increases. Generally, that phenomenon occurs particularly in machining with cutting solutions including abrasive particles. During conditioning the CMP pad with CMP conditioner, slurry particles and residues are accumulated on the surface of the CMP conditioner, thus causing a serious contamination problem on that surface.
- [5] As well known, a CMP pad is used in global planarization of a semiconductor wafer, and a CMP conditioner is a type of cutting tools for improving performance and life span of the CMP pad by removing clogging of micro pores formed in a surface of the CMP pad.
- [6] Fig. 1 shows optical microscope images illustrating changes in the magnitude of surface contamination as a function of CMP conditioning time at several test conditions. Images illustrated in Fig. 1 show the changes in the surface contamination before CMP conditioning (reference), and 30, 60, 90, 120, and 150 minutes after the CMP con-

ditioning, respectively. Referring to Fig. 1, it can be confirmed that a considerable amount of slurry contaminants is appears from 30 minutes after the CMP conditioning, and such contaminants increase while they are continuously agglomerated as the conditioning time increases.

The surface contamination of an abrasive layer of a CMP conditioner due to slurry deteriorates the efficiency of the CMP conditioning process. The deteriorated efficiency of the CMP conditioning process causes a wafer to be scratched during polishing of the wafer using a CMP pad, and lowers the production efficiency by increasing the number of particles on the wafer after the polishing.

Disclosure of Invention

Technical Problem

The present inventors have found out that a major reason for contaminating a CMP conditioner is that a surface of an abrasive layer changes to be hydrophilic according as CMP pad conditioning time increases. More specifically, the present inventors have found out that the CMP conditioner is easily contaminated since the surface of the abrasive layer of the CMP conditioner changes to be hydrophilic and the hydrophilic surface of the abrasive layer of the CMP conditioner cannot reject water containing slurry as the CMP pad conditioning process proceeds although the abrasive layer surface of the CMP conditioner has a high hydrophilicity before performing the CMP pad conditioning process. Such a problem is not limited to the CMP conditioner alone but may occur in cutting tools of wide meaning comprising abrasives which are used in cutting including cutting, grinding or polishing of narrow meaning.

An embodiment of the present invention is conceived to solve the aforementioned problems in the prior art. An embodiment of the present invention seeks to provide a cutting tool, wherein deterioration of cutting performance due to agglomeration of an abrasive layer surface and contamination of the abrasive layer surface is greatly suppressed by improving hydrophobicity maintaining performance of an abrasive layer, and a manufacturing method of the cutting tool.

Technical Solution

According to an aspect of the present invention, there is provided a method of manufacturing a cutting tool, which comprises the steps of forming an abrasive layer on a substrate, the abrasive layer having abrasives bonded to a surface thereof; coating the surface of the abrasive layer with a hydrophobic material film, wherein the coating step with the hydrophobic material film is performed by forming a self assembled molecular monolayer, in which a tail group of molecules is hydrophobic, on the surface of the abrasive layer using a deposition process; and wherein a precursor used in the deposition process has molecules of which a tail group is a CF (fluorocarbon) group or CHF (fluorohydrocarbon) group.

It is preferred that in the coating step with the hydrophobic material film, the hydrophobic material film be a self assembled molecular monolayer in which a tail group of molecules is hydrophobic. The coating step with the hydrophobic material film is preferably performed using a deposition process. At this time, a precursor used in the

deposition process has molecules of which a tail group may be hydrophobic, preferably, a CF (fluorocarbon) group or CHF (fluorohydrocarbon) group.

As the precursor, FOTS (fluorooctyltrichlorosilane), DDMS (dichlorodimethylsilane), FDA (perfluorodecanoic acid), FDTS (perfluorodecyltrichlorosilane), and OTS (octadecyltrichlorosilane) may be used.

In addition, the deposition process using the precursor may include a V-SAM (vapor-SAM) process, an L-SAM (liquid-SAM) process, and a bulk polymerization process using plasma.

The step of forming an abrasive layer may be performed using an Ni electrodeposition process or a brazing process. The cutting tool is preferably a CMP conditioner. However, the cutting tool is not limited thereto, but may be a cutting tool having a hydrophobic material film formed on a surface of the abrasive layer.

According to another aspect of the present invention, there is provided a cutting tool, which comprises a base member; an abrasive layer formed on the base member, the abrasive layer having abrasives bonded to a surface thereof; and a hydrophobic material film formed on the surface of the abrasive layer, wherein the hydrophobic material film is a self assembled molecular monolayer in which a tail group of molecules is hydrophobic; and wherein the self assembled molecular monolayer is formed by using trichlorosilane as a precursor.

Advantageous Effects

According to an embodiment of the present invention, accumulation of contaminants generated on an abrasive layer and performance deterioration of a cutting tool due to the accumulation of the contaminants are suppressed by a hydrophobic material film formed on a surface of the abrasive layer of the cutting tool. Particularly, an embodiment of the present invention can be used very effectively to suppress contaminants of a CMP conditioner that is a cutting tool used together with slurry in conditioning a CMP pad. Thus, it is possible to reduce defects such as scratches or particles generated on a processing surface of the wafer in a wafer polishing process using a CMP pad that is subjected to the CMP conditioning process.

Brief Description of the Drawings

Fig. 1 shows optical microscope images illustrating a process in which a contamination level of a conventional cutting tool varies according to cutting time of the cutting tool.

Fig. 2 shows a CMP conditioner illustrated as an embodiment of a cutting tool according to the present invention.

Figs. 3 and 4 show optical microscope images illustrating a surface of a CMP con-

ditioner after CMP pad conditioning process for 30 minutes and 60 minutes respectively, wherein the surface is coated with a hydrophobic material film.

- [21] Fig. 5 shows optical microscope images illustrating a surface of a CMP conditioner not coated with hydrophobic material film after CMP pad conditioning process for 30 minutes.
- [22] Fig. 6 is an optical microscope image showing a hydrophobicity (or hydrophilicity) test result of a CMP conditioner coated with a hydrophobic material film before a cutting process.
- [23] Fig. 7 is an optical microscope image showing a hydrophobicity (or hydrophilicity) test result of a CMP conditioner not coated with a hydrophobic material film before a cutting process.
- [24] Fig. 8 is an optical microscope image showing a hydrophobicity test result of a CMP conditioner coated with a hydrophobic material film after a cutting process.
- [25] Fig. 9 is an optical microscope image showing a hydrophobicity test result of a CMP conditioner not coated with a hydrophobic material film after a cutting process.
- [26] Figs. 10 to 13 show optical microscope images illustrating a surface of CMP conditioner coated with a hydrophobic material film, after CMP pad conditioning process for 20 hours under the same condition as in an actual working field.
- [27] Figs. 14 to 17 show optical microscope illustrating a surface of CMP conditioner not coated with a hydrophobic material film, after CMP pad conditioning process for 20 hours under the same condition as in an actual working field.

Best Mode for Carrying Out the Invention

- [28] Hereinafter, a CMP conditioner, as an example of a cutting tool according to the present invention, will be described. The following embodiments are provided only for illustrative purposes so that those skilled in the art can fully understand the spirit of the present invention. Therefore, the present invention is not limited to the following embodiments but may be implemented in other forms. In the drawings, the widths, lengths, thicknesses and the like of elements may be exaggerated for convenience of illustration. Like reference numerals indicate like elements throughout the specification and drawings.
- [29] Fig. 2 shows a CMP conditioner illustrated as an embodiment of a cutting tool according to the present invention. Referring to Fig. 2, a CMP conditioner 1 according to the present invention comprises a substrate 10 and an abrasive layer 20. The substrate 10 is made of a metallic material and has a generally disc-shaped structure. The abrasive layer 20 is formed on the substrate 10 and has a plurality of abrasives 21. In this embodiment, the abrasive layer 20 is an Ni electrodeposition layer formed by being plated with Ni to hold the abrasives 21, and the abrasives 21 protrude from a

surface of the abrasive layer 20.

- [30] As illustrated from an enlarged view of Fig. 2, a hydrophobic material layer 30 is formed on the surface of the abrasive layer 20. The hydrophobic material layer 30 is a film having a hydrophobic surface of which a surface contact angle to water is large, and the hydrophobic material layer 30 serves to prevent the surface of the abrasive layer 20 from tending to be hydrophilic according to an increase in use time of the CMP conditioner 1.
- [31] The hydrophobic material layer 30 is a coating film, which may be formed by a deposition process or other processes, and covers both the electrodeposition material and abrasives 21. At this time, since the hydrophobic material layer 30 is a thin film with a thickness smaller than a protruding height of the abrasives 21, the performance of the CMP conditioner 1 is not deteriorated although the hydrophobic material layer 30 is formed on the abrasives 21.
- [32] Although an extremely small portion of the hydrophobic material layer 30 formed on the abrasives 21 may be eliminated if using the CMP conditioner 1 in conditioning of a CMP pad, another large portion of the surface of the abrasive layer 20, i.e., a surface of an electrodeposition material holding the abrasives 21 can be always maintained at its position unless the abrasives 21 are removed or worn out.
- [33] The hydrophobic material layer 30 is preferably formed as a self assembled molecular monolayer in which a tail group of molecules is hydrophobic. Hereinafter, one embodiment of the present invention, in which a hydrophobic self assembled molecular monolayer is formed on the surface of the abrasive layer, will be described.
- [34] A technique of forming a self assembled molecular monolayer (also referred to as 'self assembled monolayer'), which is included in a nano technology, is at the zenith of a technique for changing surface properties of an arbitrary material by a nano-based micro thin film. The self assembled molecular monolayer comprises a head group reacting with a surface of an arbitrary material, a body for determining a length of the arbitrary material, and a tail group for determining the surface properties of the arbitrary material, wherein when the tail group is hydrophobic, the surface properties of the self assembled molecular monolayer become hydrophobic.
- [35] A process for vaporizing a material and depositing the vaporized material on a surface of an abrasive layer 20 of a CMP conditioner 1 is used in this embodiment, and one exemplification of the process will be described in the following Example 1.

Mode for the Invention

- [36] [Example 1: Process of forming hydrophobic material film]
- [37] A hydrophobic material film consisted of a self assembled molecular monolayer was deposited on a surface of an abrasive layer of the CMP conditioner by charging a CMP

conditioner, on which a hydrophobic material film was not formed, into a process chamber. At this time, trichlorosilane with formula $C_8H_4Cl_3F_{13}Si$ was used as a precursor for the hydrophobic material film. The deposition conditions were: a vacuum degree of 10 to 21 torr; a process temperature of 150°C; and a reaction time of 10 minutes. An Ni 4 conditioner made by Shinhan Diamond Corporation was used as the CMP conditioner.

- [38] Since it is hard to grasp whether the hydrophobic material film is formed or not through the naked eye or optical microscopic observation, whether the hydrophobic material film is formed was confirmed through a contamination degree varying test and a hydrophobic (or hydrophilic) test during processing of the CMP conditioner.
- [39]
- [40] [Example 2: Contamination degree varying test (Slurry agglomeration varying test)]
- [41] A process for conditioning an actual CMP pad was performed using the CMP conditioner that was subjected to the process of Example 1, and the contamination degree of the CMP conditioner was inspected at time intervals of 30 minutes during the process.
- [42] The CMP conditioning process was performed using distilled water at a slurry flow rate of 200 ml/min, a rotational speed of 50 rpm of the CMP pad and conditioner and an applied pressure of 8.5 psi thereof. The slurry was Star4000 made by Cheil Industries INC., and the CMP pad was IC1010 made by Rohm & Hass Company. The foregoing conditions are conditions in which the applied pressure and the slurry flow rate was increased as compared with the actual CMP conditioning process in order to confirm the change in a contamination degree of the CMP pad for a short time. For reference, a contamination degree varying test performed under the same conditions as the CMP conditions at the actual working field will be also described in Example 4, which will be described later.
- [43] Figs. 3 and 4 are optical microscopic images in which a surface of an abrasive layer of the CMP conditioner is photographed at magnifying powers of $\times 100$, $\times 200$, $\times 500$, and $\times 1000$ after performing the CMP conditioning process using a CMP conditioner for 30 and 60 minutes, respectively.
- [44] As illustrated in Figs. 3 and 4, it can be confirmed that a CMP conditioner in which a hydrophobic material film is formed on the surface of the abrasive layer through Example 1 was hardly contaminated by the slurry except that a contamination area of more or less 5% is found. The contamination area seems to be influenced by unknown external factors during the test.
- [45]
- [46] [Comparative Example 1: Contamination degree varying test (Slurry agglomeration varying test)]

- [47] A CMP pad conditioning process was performed using a CMP conditioner that was not subjected to the process of Example 1, i.e., a CMP conditioner on which a hydrophobic material film was not formed, and the contamination degree of the CMP conditioner was inspected at time intervals of 30 minutes during the process. Test conditions except the CMP conditioner used in the test were identical to those of Example 2.
- [48] That is, the CMP conditioning process was performed, as in Example 2, using distilled water at a slurry flow rate of 200 ml/min, a rotational speed of 50 rpm of the CMP pad and conditioner and an applied pressure of 8.5 psi thereof.
- [49] Fig. 5 is optical microscopic images in which a surface of the CMP conditioner is photographed at magnifying powers of $\times 100$, $\times 200$, $\times 500$, and $\times 1000$ after performing the CMP conditioning process for 30 minutes.
- [50] As illustrated in Fig. 5, it can be confirmed that a surface of an abrasive layer is contaminated by slurry. It can also be confirmed that accumulation of contamination by the slurry is more increased as time goes by. It can be seen from the test results that contaminants are more accumulated by the slurry on the CMP conditioner not coated with a hydrophobic material film.
- [51]
- [52] [Example 3: Hydrophobic test (Hydrophilic test)]
- [53] Fig. 6 is an optical microscope image showing a hydrophobicity test result of a CMP conditioner coated with a hydrophobic material film, wherein the CMP conditioner has a contact angle of 110 or more. Fig. 7 is an optical microscope image showing a hydrophobicity test result of a CMP conditioner not coated with a hydrophobic material film, wherein the CMP conditioner has a contact angle of 70°. Figs. 6 and 7 show hydrophobicity test results of the CMP conditioners before the CMP conditioning process is performed.
- [54] Comparing Figs. 6 and 7 with each other, it can be seen that the CMP conditioner coated with the hydrophobic material film has a better hydrophobicity than the CMP conditioner not coated with the hydrophobic material film since the CMP conditioner coated with the hydrophobic material film has a larger contact angle than the CMP conditioner not coated with the hydrophobic material film.
- [55] Fig. 8 is an optical microscope image showing a hydrophobicity test result of the CMP conditioner after performing a CMP conditioning process using a CMP conditioner coated with a hydrophobic material film. It can be seen that Fig. 8 does not show a large difference from Fig. 6, i.e., the image showing a hydrophobicity test result of the CMP conditioner before the CMP conditioning process. This shows that hydrophobicity of a surface of the hydrophobic material film is maintained as it is even after the CMP conditioning process.

- [56] On the contrary, it can be seen that a water drop cannot be found on the CMP conditioner not coated with the hydrophobic material film as illustrated in Fig. 9. This shows that hydrophobicity of the CMP conditioner was completely lost while a CMP conditioning process was performed using the CMP conditioner, so that the CMP conditioner became hydrophilic. At this time, a measured contact angle of the CMP conditioner was less than 5°
- [57]
- [58] [Example 4: Contamination degree varying test (Slurry agglomeration varying test)]
- [59] A CMP pad conditioning process for 20 hours under the same conditions as the actual labor site was performed using a CMP conditioner manufactured through the process of Example 1, and a contamination degree of the CMP conditioner was inspected while performing the process. As compared with Example 2, the CMP conditioning process was performed at greatly reduced slurry flow rate and pressure applied to the CMP pad.
- [60] The CMP conditioning process was performed using distilled water at a slurry flow rate of 60 ml/min, a rotational speed of 65 rpm of the CMP pad and conditioner, and an applied pressure of 0.63 psi thereof. The slurry was HS-1100H available from Hanhwa Chemical Corporation, and the CMP pad was IC1010 made by Rohm and Hass Company. The foregoing conditions are conditions in which the applied pressure was increased as compared with the actual CMP conditioning process in order to confirm the change in a contamination degree of the CMP pad for a short time.
- [61] Figs. 10 to 13 are optical microscopic images in which a surface of the CMP conditioner is photographed at magnifying powers of $\times 100$, $\times 200$, $\times 500$, and $\times 1000$ respectively after performing the CMP conditioning process for 20 hours according to the foregoing conditions.
- [62] It can be seen from images of Figs. 10 to 13 that the CMP conditioner is hardly contaminated by slurry. Therefore, it is possible to obtain the results that a CMP conditioner coated with a hydrophobic material film is hardly contaminated even in the actual process and such an effect is sustained for a long time.
- [63]
- [64] [Comparative Example 2: Contamination degree varying test (Slurry agglomeration varying test)]
- [65] A process for conditioning an actual CMP pad was performed for 20 hours using a CMP conditioner that was not subjected to the process of Example 1, i.e., a CMP conditioner on which a hydrophobic material film was not formed. Test conditions except the CMP conditioner were identical to those of Example 4.
- [66] Figs. 14 to 17 are optical microscopic images in which a surface of a CMP conditioner is photographed at magnifying powers of $\times 100$, $\times 200$, $\times 500$, and $\times 1000$, re-

spectively, after performing the CMP conditioning process for 20 hours according to the foregoing conditions using a CMP conditioner without a hydrophobic material film.

[67] As can be seen from the images of Figs. 14 to 17, it can be confirmed that the entire area on a surface of an abrasive layer was greatly contaminated by slurry. Therefore, it can be confirmed again that accumulation of contaminants by the slurry is more increased in the CMP conditioner not coated with a hydrophobic material film as compared with the CMP conditioner coated with a hydrophobic material film.

[68]

[69] Although a coating method of a hydrophobic material film using FOTS (fluorooctyltrichlorosilane) as a precursor has been described above, DDMS (dichlorodimethylsilane), FDA (perfluorodecanoic acid), FDTS (perfluorodecyltrichlorosilane), and OTS (octadecyltrichlorosilane) may be used as the precursor. Furthermore, the deposition process using the precursor includes a V-SAM (vapor-SAM) process, an L-SAM (liquid-SAM) process, and a bulk polymerization process using plasma.

CLAIMS

- [1] A method of manufacturing a cutting tool, comprising the steps of:
forming an abrasive layer on a base member, the abrasive layer having abrasives bonded to a surface thereof;
coating the surface of the abrasive layer with a hydrophobic material film, wherein the coating step with the hydrophobic material film is performed by forming a self assembled molecular monolayer, in which a tail group of molecules is hydrophobic, on the surface of the abrasive layer using a deposition process; and wherein a precursor used in the deposition process has molecules of which a tail group is a CF (fluorocarbon) group or CHF (fluorohydrocarbon) group.
- [2] The method as claimed in claim 1, wherein the step of forming the abrasive layer is performed using an Ni electrodeposition process.
- [3] A cutting tool, comprising:
a base member;
an abrasive layer formed on the base member, the abrasive layer having abrasives bonded to a surface thereof;
a hydrophobic material film formed on the surface of the abrasive layer; wherein the hydrophobic material film is a self assembled molecular monolayer in which a tail group of molecules is hydrophobic; and wherein the self assembled molecular monolayer is formed by using trichlorosilane as a precursor.
- [4] The cutting tool as claimed in claim 3, wherein the abrasive layer is an Ni electrodeposition layer to which the abrasives are bonded.
- [5] The cutting tool as claimed in claim 3, wherein the cutting tool is a CMP conditioner.