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(54) **POLISHING HEAD AND CHEMICAL MECHANICAL POLISHING PROCESS USING THE SAME**

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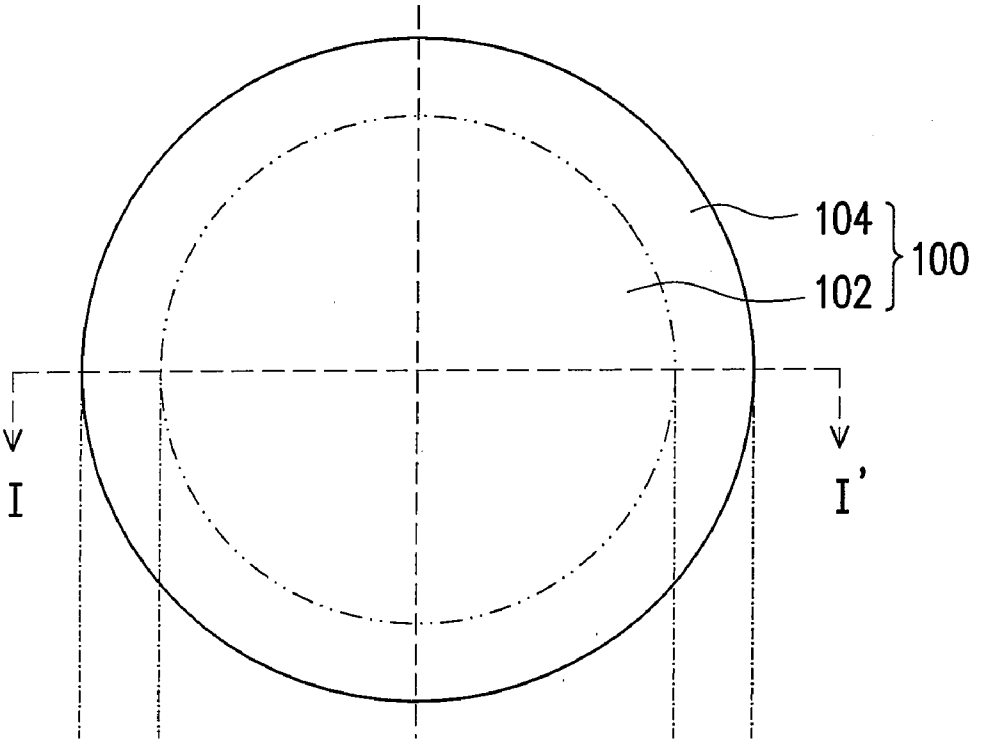
(57) **ABSTRACT**

A polishing head for a chemical mechanical polishing process is provided. The polishing head includes an inner circle part and an outer circle part. The outer circle part is a ring-like structure that is connected to the inner circle part. The inner circle part and the outer circle part are an integrated structure. There is a level difference between the respective surfaces of the outer circle part and the inner circle part. Further, the surface of the outer circle part is higher than that of the inner circle part.



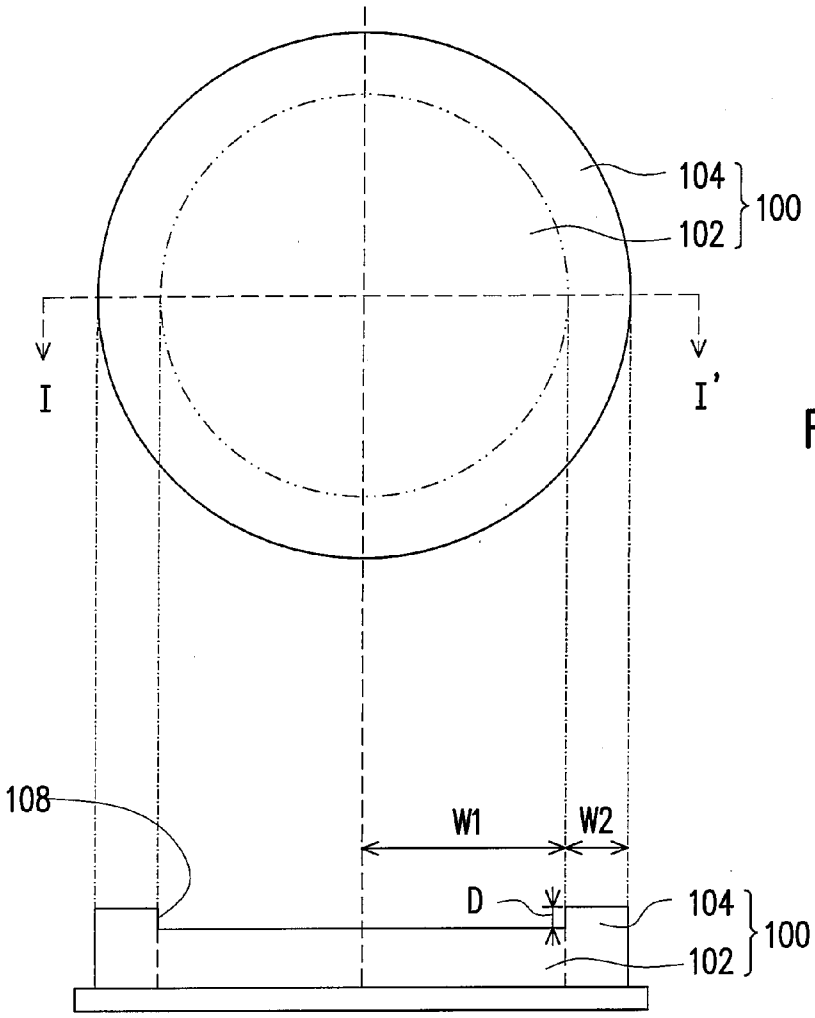


FIG. 1A

FIG. 1B

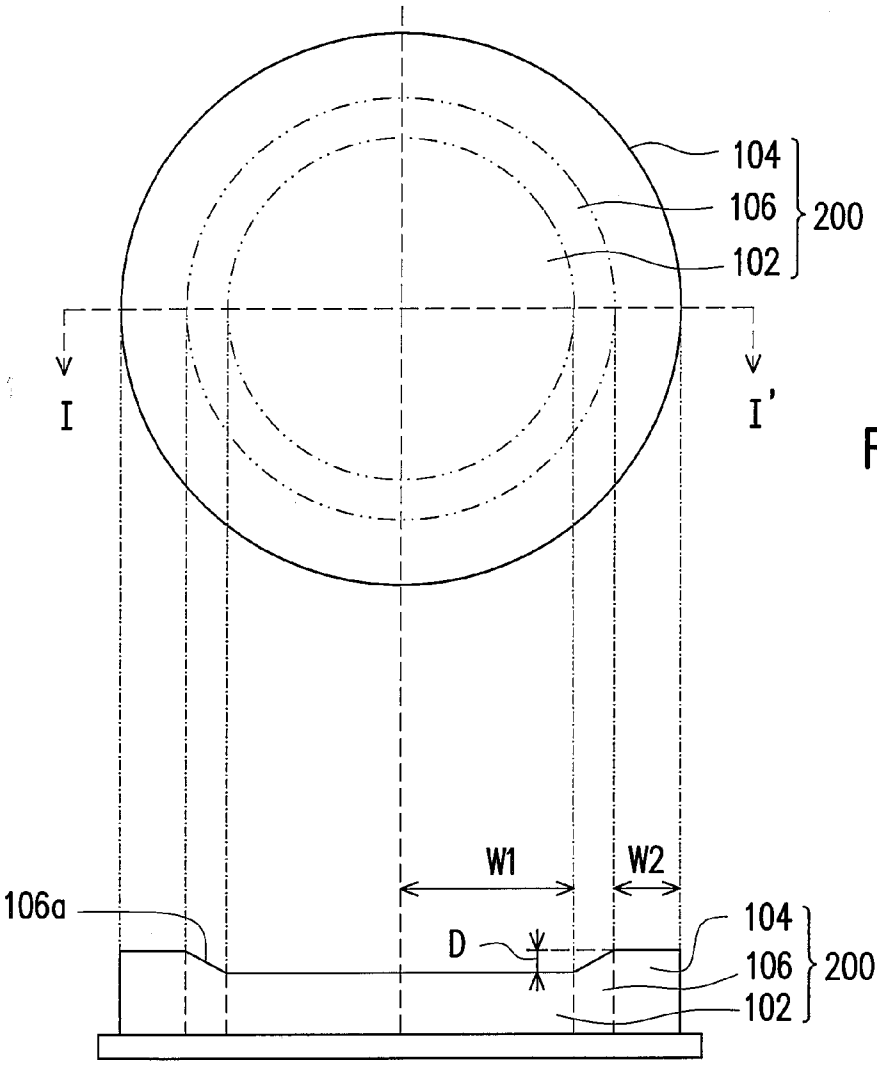


FIG. 1C

FIG. 1D

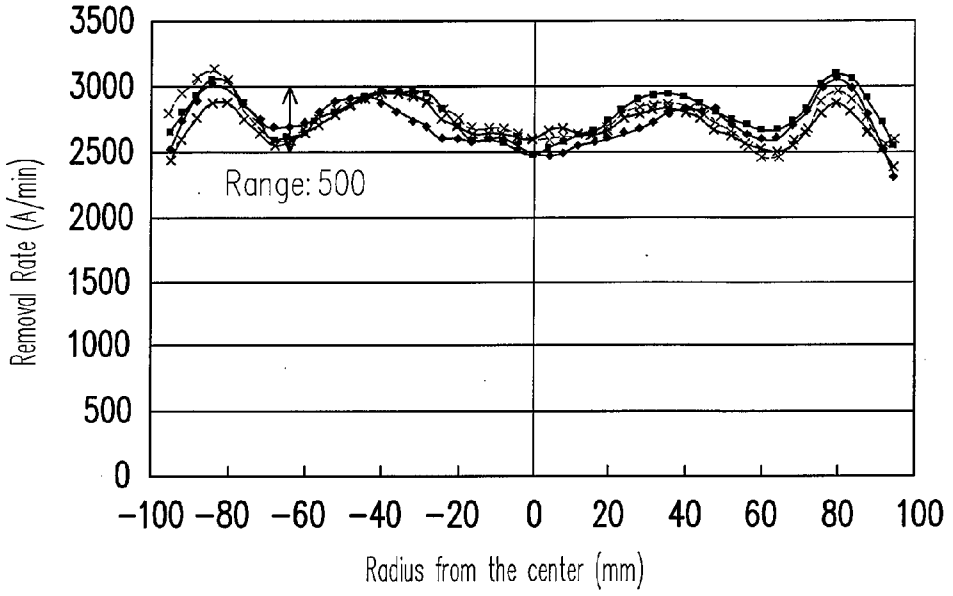

3500
3000
2500
2000
1500
1000
500
0
Removal Rate (A/min)
Range: 500
−100 −80 −60 −40 −20 0 20 40 60 80 100
Radius from the center (mm)

FIG. 2

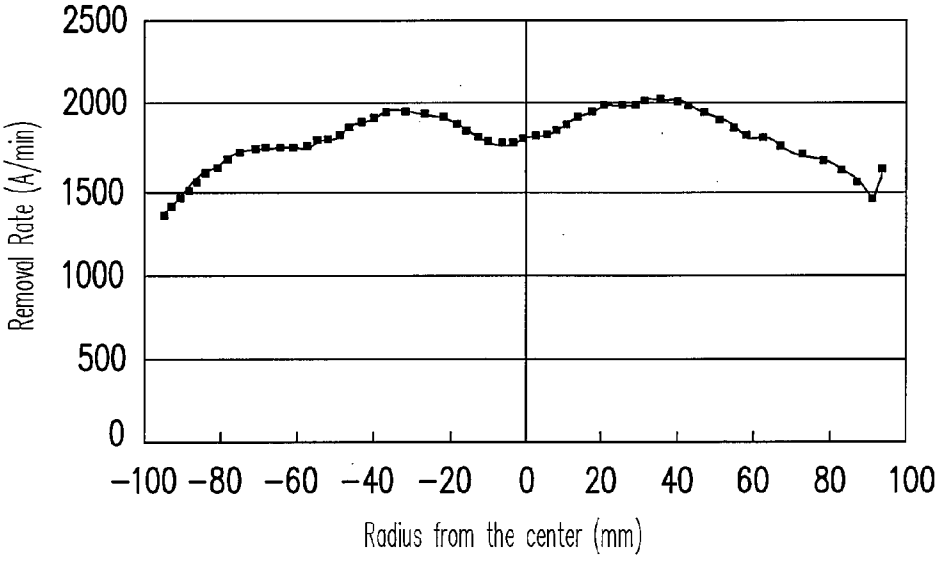

2500
2000
1500
1000
500
0
Removal Rate (A/min)
−100 −80 −60 −40 −20 0 20 40 60 80 100
Radius from the center (mm)

FIG. 3

POLISHING HEAD AND CHEMICAL MECHANICAL POLISHING PROCESS USING THE SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to an integrated circuit device, a method for fabricating the same, and its application. More particularly, the present invention relates to a polishing head, a method for fabricating the same and a chemical mechanical polishing (CMP) process that utilizes the polishing head.

[0003] 2. Description of Related Art

[0004] In semiconductor fabrication techniques, the principle behind chemical mechanical polishing (CMP) is similar to the mechanical principle behind knife grinding. The process works in conjunction with an appropriate chemical reagent to planarize the uneven topography of the wafer on the polishing pad. Generally, in a chemical mechanical polishing device, a wafer is usually held by a polishing head and the wafer is pressed against the polishing pad face down and the polishing pad is supplied with slurry for polishing. During the chemical mechanical polishing process, due to the limitations of the device structures, the pressure applied to the polishing head is not uniform across the whole polishing head, causing varying removal rate over the surface of the wafer.

[0005] Conventionally, the prior art overcomes the above-mentioned problem by adjusting the backside pressure applied to the polishing head by floating backside pressure using air bag, for example. However, using floating pressure to adjust the backside pressure applied to the polishing head cannot be easily achieved because air pressure control is unstable. Hence, this way of applying pressure does not provide satisfying results. Additionally, among the prior art, another solution to overcome the above-mentioned problem has been proposed, which includes covering the even surface of the polishing head with a carrier film and covering the portion of the polishing head where the removal rate is lower, such as the edge of the polishing head, with an additional tape on top of the carrier film for applying a greater pressure. Nevertheless, the thickness of the tape added to the polishing head must be extremely thin, usually around 30 μm, which makes it harder to control the quality of the tape used during the fabrication process. Hence, the two aforementioned solutions proposed by the prior art are limited in improving the removal rate uniformity due to unstable control of air pressure or variation in the quality of the consumable materials such as a carrier film or tap.

SUMMARY OF THE INVENTION

[0006] The present invention is directed to a polishing head that does not require consumable materials to improve the removal rate around the edge of the polishing head and the removal rate uniformity.

[0007] The present invention is directed to a polishing head that is suitable for use in chemical mechanical polishing process. The polishing head includes an inner circle part and an outer circle part. The outer circle part is a ring-like structure that is connected to the inner circle part. Further, the inner circle part and the outer circle part are an integrated structure. In addition, there is a level difference between the surface of the outer circle part and that of the inner circle part such that the surface of the outer circle part is higher than that of the inner circle part.

[0008] In an embodiment of the present invention, the above-mentioned level difference is between 5 μm and 35 μm.

[0009] In an embodiment of the present invention, the above-mentioned level difference is 10 μm.

[0010] In an embodiment of the present invention, the inner circle part is a circle and the outer circle part is a ring.

[0011] In an embodiment of the present invention, the ratio of the radius of the circle to the width of the ring is between 2:1 and 5:1.

[0012] In an embodiment of the present invention, the ratio of the radius of circle to the width of the ring is 3:1.

[0013] In an embodiment of the present invention, the outer circle part is adjacent to the edge of the inner circle part. Moreover, the junction between the inner circle part and the outer circle part is perpendicular.

[0014] In an embodiment of the present invention, a connecting ring is further included between the inner circle part and the outer circle part to connect the inner circle part to the outer circle part.

[0015] In an embodiment of the present invention, the surface of the above-mentioned connecting ring is slanted.

[0016] The present invention is also directed to a chemical mechanical polishing (CMP) process. First, the wafer is held on the polishing pad by the polishing head. Herein, the polishing head has a concave-convex configuration. Next, a fixed backside pressure is applied to the polishing head and the different pressures are applied to the different regions of the wafer by the concave-convex configuration of the polishing head. Thereafter, the polishing pad and the wafer are moved relatively.

[0017] In an embodiment of the present invention, the above-mentioned concave-convex configuration includes a concave part and a convex part. Herein, there is a level difference between the concave part and the convex part.

[0018] In an embodiment of the present invention, the above-mentioned level difference is between 5 μm and 35 μm.

[0019] In an embodiment of the present invention, the concave part is the inner circle part and the convex part is the outer circle part. Herein, the outer circle part is connected to the inner circle part.

[0020] In an embodiment of the present invention, the inner circle part is a circle and the outer circle part is a ring.

[0021] In an embodiment of the present invention, the ratio of the radius of the circle to the width of the ring is between 2:1 and 5:1.

[0022] In an embodiment of the present invention, the outer circle part is adjacent to the edge of the inner circle part. Moreover, the junction between the inner circle part and the outer circle part is perpendicular.

[0023] In an embodiment of the present invention, a connecting ring is further included between the inner circle part and the outer circle part to connect the inner circle part to the outer circle part.

[0024] In an embodiment of the present invention, the surface of the above-mentioned connecting ring is slanted.

[0025] The polishing head of the present invention utilizes its uneven surface profile to improve the removal rate at the edge region of the wafer. Since the surface of the outer circle part of the polishing head is higher than that of the inner circle

part of the polishing head, the removal rate of the edge region of the wafer is increased to improve the removal rate uniformity.

[0026] Further, the method for fabricating the polishing head of the present invention utilizes cutting or grinding a rigid material on a plane to alter the surface profile of the polishing head without using consumable materials such as carrier film or tape. Therefore, the problem of using materials of varying quality which affects the removal rate can be avoided. Further, the manufacturing cost for the polishing head is reduced because less consumable materials are needed to fabricate the polishing head.

[0027] Additionally, the chemical mechanical polishing process of the present invention utilizes a polishing head having a concave-convex configuration to polish wafers. Therefore, when a fixed backside pressure is applied to the polishing head, a greater pressure is applied to the outer circle part of the polishing head. Hence, the overall removal rate can be adjusted and the uniformity of the wafer surface can be improved.

[0028] In order to make the aforementioned and other objects, features and advantages of the present invention more comprehensible, preferred embodiments accompanied with figures are described in detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] FIG. **1**A is a schematic top view illustrating a polishing head according to an embodiment of the present invention.

[0030] FIG. **1**B is a schematic cross-sectional view illustrating the polishing head shown in FIG. **1**A along the line I-I'.

[0031] FIG. **1**C is a schematic top view illustrating a polishing head according to another embodiment of the present invention.

[0032] FIG. **1**D is a schematic cross-sectional view illustrating the polishing head shown in FIG. **1**C along the line I-I'.

[0033] FIG. **2** is a graph illustrating the distribution of the removal rate during a chemical polishing process using the polishing head of the present invention.

[0034] FIG. **3** is a graph illustrating the distribution of the removal rate during a chemical polishing process using a conventional polishing head covered with a carrier film.

DESCRIPTION OF EMBODIMENTS

[0035] FIG. **1**A is a schematic top view illustrating a polishing head according to an embodiment of the present invention. FIG. **1**B is a schematic cross-sectional view illustrating the polishing head shown in FIG. **1**A along the line I-I'.

[0036] Please refer to FIG. **1**A. A polishing head **100** suitable for chemical mechanical polishing process is, for example, a circular structure. The polishing head **100** includes an inner circle part **102** and an outer circle part **104**. In the present embodiment, the inner circle part **102** is a solid circular structure and the outer circle part **104** is a ring structure. The edge of the inner circle part **102** is bordered by the outer circle part **104**. Further, the inner fringe of the outer circle part **104** is adjacent to the edge of the inner circle part **102**. Additionally, the junction **108** between the inner circle part **102** and the outer circle part **104** is perpendicular. Further, the inner circle part **102** and the outer circle part **104** are an integrated structure. In other words, viewing from the top, the polishing head **100**, the inner circle part **102** and the ring-like outer circle part **104** look, for example, like a concentric structure.

[0037] Please refer to FIG. **1**A and FIG. **1**B, particularly the radius of the polishing head **100** at cross-section. The ratio of the radius W**1** of the inner circle part **102** to the width W**2** of the outer circle part **104** is, for example, between 2:1 and 5:1. On the other hand, the width W**2** of the outer circle part **104** is, for example, greater than the radius W**1** of the inner circle part **102**. Further, the surface of the outer circle part **104** is higher than that of the inner circle part **102**. In addition, the level difference D between the inner circle part **102** and the outer circle part **104** is between 5 μm and 35 μm. In an embodiment, the radius of the polishing head **100** is 100 mm, the radius W**1** of the inner circle part **102** is 75 mm, the width W**2** of the ring-like outer circle part **104** is 25 mm, and the level difference D between the surface of the outer circle part **104** and that of the inner circle part **102** is 10 μm.

[0038] FIG. **1**C is a schematic top view illustrating a polishing head according to another embodiment of the present invention. FIG. **1**D is a schematic cross-sectional view illustrating the polishing head shown in FIG. **1**C along the line I-I'. The same reference numbers used in FIG. **1**A and FIG. **1**B are used to refer to the same parts in FIG. **1**C and FIG. **1**D. Hence, a detailed description thereof is omitted.

[0039] Referring to FIG. **1**C and FIG. **1**D, the present invention is also directed to a polishing head **200** that is suitable for use in chemical mechanical polishing process. The basic components of the polishing head **200** are similar to that of the polishing head **100**. However, the polishing head **200** differs from the polishing head **100** in that it includes a connecting ring **106** between the inner circle part **102** and the outer circle part **104** that connects the inner circle part **102** and the outer circle part **104**. The connecting ring **106** is a ring-like structure and the inner fringe of the connecting ring **106** is adjacent to the inner circle part **102** while the edge of the connecting ring **106** is adjacent to the outer circle part **104**. A surface **106**a of the connecting ring **106** is, for example, slanted. Further, the slanted surface **106**a may connect the surface of the inner circle part **102** to the surface of the outer circle part **104**. It should be noted that the number and the surface structure of the connecting ring **106** are not limited to what are shown in FIG. **1**D. More specifically, as long as the connecting ring **106** can connect the inner circle part **102** and the outer circle part **104** to form an integrated structure, the present invention is not limited thereto.

[0040] Referring to FIG. **1**B and FIG. **1**D, the polishing head **100** and the polishing head **200** have a concave-convex configuration including a concave part and a convex part. The above-mentioned inner circle part **102** is the concave part and the outer circle part **104** is the convex part. Certainly, in other embodiments, the concave part and convex part of the polishing head **100** or the polishing head **200** are not limited to the arrangement described above for the inner circle part **102** and the outer circle part **104**. Those of ordinary skill in the art may make modifications accordingly.

[0041] In view of the above, the inner circle part **102** and the outer circle part **104** are an integrated structure. Hence, the polishing head **100** and the polishing head **200** are formed on a rigid material having an even surface (not shown) such as the body of a planar polishing head. The portion of rigid material along the inner fringe where the removal rate is higher is removed to form the inner circle part **102**, and the edge where the removal rate is lower is retained to form the

outer circle part **104**. The method used for removing the rigid material is, for example, by cutting or grinding downward to form the inner circle part **102** and the outer circle part **104** having a level difference D therebetween. The level difference D is adjusted by controlling the amount of the downward cutting or the depth of the grinding. Certainly, the radius W1 of the inner circle part **102** and the level difference D may be adjusted according to the surface profile of the polished material layer using the polishing head **100** or the polishing head **200** in the subsequent chemical mechanical polishing process to achieve optimized conditions. Further, the present invention does not limit the location where a portion of the rigid material is removed to where the inner circle part **102** is formed as shown in the figure. Specifically, the region where a portion of the rigid material is removed may be any region where the removal rate is higher and needs to be adjusted. Those of ordinary skill in the art may make modifications accordingly.

[0042] It should be noted that, in the polishing head **100** and the polishing head **200**, the outer circle part **104** having a higher surface is conventionally disposed on the region with a lower removal rate in a conventional planar polishing head. However, when the above-mentioned polishing head **100** and the polishing head **200** are used to perform chemical mechanical polishing process, the wafer (not shown) is first held by the polishing head **100** or the polishing head **200** on the polishing pad (now shown). Herein, the polishing pad is, for example, covered with slurry. Thereafter, a fixed backside pressure is applied to the polishing head **100** or the polishing head **200**, and the polishing pad and the wafer are relatively moved during the polishing step. Since the polishing head **100** and the polishing head **200** have a concave-convex configuration, the polishing head **100** and the polishing head **200** may still be used to provide different pressures to the different regions of the wafer because of the difference in the surface profile though the backside pressure applied. More specifically, the outer circle part **104** that forms the convex part applies a greater pressure to the wafer. Therefore, during the polishing step, the removal rate around the edge of the polishing head **100** and that of the polishing head **200** are improved and the removal rate uniformity is also improved.

[0043] To prove the effects of the polishing head of the present invention, an experiment is described below to illustrate the desired result of the polishing head of the present invention when used in a chemical mechanical polishing process.

Experiment(s)

[0044] FIG. **2** is a graph illustrating the distribution of the removal rate during a chemical polishing process using the polishing head (the polishing head **100** shown in FIG. 1B) of the present invention.

[0045] Referring to FIG. **2**, when using the polishing head of the present invention to perform a chemical mechanical polishing process, the wafer is mounted on the polishing head of the present invention and a fixed backside pressure is applied to the polishing head to press the wafer against the polishing pad for performing the polishing step. As shown in FIG. **2**, the removal rate around the edge that is far from the center is effectively improved and the overall removal rate uniformity is also improved (the removal rate uniformity is 500 A/min). Further, according to FIG. **2**, the distributions of four different sets of data are relatively consistent, demonstrating the polishing head of the present invention performs consistently.

COMPARATIVE EXAMPLES

[0046] FIG. **3** is a graph illustrating the distribution of the removal rate during a chemical polishing process using a conventional polishing head covered with a carrier film.

[0047] The methods used for performing the chemical mechanical polishing processes in the comparative example are similar to that of the experiment (FIG. **2**), except the polishing heads are different. Please refer to FIG. **3**. When using a polishing head covered with only a carrier film to perform a chemical mechanical polishing process, the surface of the planar polishing head results in varying removal rate in different regions. More specifically, the removal rate around the edge of the polishing head that is far from the center is particularly lower. As a result, the removal rate uniformity is poor.

[0048] Based on the results obtained from real tests, the polishing head of the present invention not only improve the removal rate around the edge of the polishing head, but also the removal rate uniformity. Further, the removal rate is ensured to be consistent.

[0049] In view of the above, the inner circle part of the polishing head of the present invention forms a concave part and the outer circle part of the polishing head forms a convex part. A fixed backside pressure is applied to the polishing head when performing a chemical mechanical polishing process to ensure the removal rate around the edge of the polishing head is improved due to the pressure change resulted by the concave-convex configuration of the polishing head. Hence, the removal rate of the outer circle part is improved and better removal rate uniformity is achieved.

[0050] On the other hand, the polishing head of the present invention utilizes a fixed rigid structure without additional use of consumable materials such as a carrier film or tape to avoid inconsistent removal rate resulted by the consumable materials of varying quality used. Additionally, it is easier to achieve optimized conditions when fabricating an integrated structure. Hence, a larger process window can be accomplished.

[0051] Furthermore, the present invention uses simple methods to change the surface profile of the polishing head to adjust the removal rate at some regions and improve the removal rate uniformity without using additional consumable materials, thus saving the manufacturing costs.

[0052] It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the present invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the present invention cover modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.

What is claimed is:

1. A polishing head suitable for use in a chemical mechanical polishing process, comprising:

an inner circle part; and

an outer circle part, wherein the outer circle part is a ring-like structure that is connected to the inner circle part, the inner circle part and the outer circle part are an integrated structure, and there is a level difference between the surface of the outer circle part and the

surface of the inner circle part such that the surface of the outer circle part higher than the surface of the inner circle part.

2. The polishing head of claim **1**, wherein the level difference is between 5 μm and 35 μm.

3. The polishing head of claim **2**, wherein the level difference is 10 μm.

4. The polishing head of claim **1**, wherein the inner circle part is a circle and the outer circle part is a ring.

5. The polishing head of claim **4**, wherein the ratio of the radius of the circle to the width of the ring is between 2:1 and 5:1.

6. The polishing head of claim **5**, wherein the ratio of the radius of the circle to the width of the ring is 3:1.

7. The polishing head of claim **1**, wherein the outer circle part is adjacent to the edge of the inner circle part and a junction between the inner circle part and the outer circle part is perpendicular.

8. The polishing head of claim **1**, further comprising a connecting ring between the inner circle part and the outer circle part that connects the inner circle part to the outer circle part.

9. The polishing head of claim **8**, wherein a surface of the connecting ring is slanted.

10. A chemical mechanical polishing process, comprising:

holding a wafer on a polishing pad by a polishing head, wherein the polishing head has a concave-convex configuration.

applying a fixed backside pressure to the polishing head to apply different pressures to the different regions of the wafer through the concave-convex configuration of the polishing head; and

moving the polishing pad and the wafer relatively.

11. The chemical mechanical polishing process of claim **10**, wherein the polishing head having the concave-convex configuration comprises a concave part and a convex part, and there is a level difference between the concave part and the convex part.

12. The chemical mechanical polishing process of claim **11**, wherein the level difference is between 5 μm and 35 μm.

13. The chemical mechanical polishing process of claim **11**, wherein the concave part is an inner circle part, the convex part is an outer circle part, and the inner circle part is connected to the outer circle part.

14. The chemical mechanical polishing process of claim **13**, wherein the inner circle part is a circle and the outer circle part is a ring.

15. The chemical mechanical polishing process of claim **14**, wherein the ratio of the radius of the circle to the width of the ring is between 2:1 and 5:1.

16. The chemical mechanical polishing process of claim **13**, wherein the outer circle part is adjacent to the edge of the inner circle part and a junction between the inner circle part and the outer circle part is perpendicular.

17. The chemical mechanical polishing process of claim **13**, further comprising a connecting ring between the inner circle part and the outer circle part that connects the inner circle part to the outer circle part.

18. The chemical mechanical polishing process of claim **17**, wherein a surface of the connecting ring is slanted.

* * * * *