

SPECIFICATION

METHOD OF MANUFACTURING CHUCK PLATE FOR USE IN ELECTROSTATIC CHUCK

[Technical Field]

[0001] The present invention relates to a method of manufacturing a chuck plate, as a dielectric body, for use in an electrostatic chuck which serves to attract and hold a substrate to be processed (hereinafter also referred to as a "to-be-processed substrate") such as a silicon wafer or the like.

[Background Art]

[0002] In order to obtain a desired device structure in semiconductor manufacturing processes, there are performed processing operations: such as a film-forming processing by PVD method, CVD method or the like; ion implantation processing; etching processing; or the like. In vacuum processing apparatuses for performing these processing operations, so-called electrostatic chucks are disposed in order to hold in position silicon wafers (hereinafter simply referred to as "wafers") in processing chambers in a vacuum atmosphere. As an electrostatic chuck, there is conventionally known in Patent Document 1 a so-called dipolar type in which a chuck plate as a dielectric body is mounted on an upper surface of a chuck main body having mounted by burying therein positive and negative electrodes.

[0003] Further, depending on the processing operations to be performed inside the vacuum processing apparatus, there are cases where a substrate is controlled to a predetermined temperature. In such a case, it is known: to assemble into the chuck main body or the like a heating means, e.g., of electric resistance type; to form a rib portion which comes into surface contact with a peripheral edge portion on a rear surface (the side opposite to the surface on which a predetermined processing is performed) of the wafer;

and to vertically dispose a plurality of supporting portions, e.g., in a concentric manner in an inner space enclosed by the rib portion. At the time of heating or cooling the wafer, an inert gas such as Ar gas or the like is supplied to the inner space through a gas passage formed in the chuck main body. By thus forming an inert gas atmosphere in the inner space defined by the rib portion and the rear surface of the wafer, heat transfer from the chuck main body to the wafer is assisted to thereby efficiently heat or cool the wafer.

[0004] Here, as the chuck plate for use in the electrostatic chuck, there is used a sintered body which exhibits a high electrical resistance such as aluminum nitride, silicon nitride or the like. However, if an arrangement is made to form the inert gas atmosphere as described above, the area of contact with the wafer naturally becomes smaller. Therefore, in order to arrange such that the wafer gets surely attracted without incurring an increase in the voltage to be applied to the electrodes, it is necessary to fabricate the surface of contact of the chuck plate with the wafer, i.e., the upper surface of the rib portion and projected portions to a predetermined surface roughness and degree of flatness.

[0005] In view of the above, it is known in, e.g., Patent Document 2 to impregnate a sintered body with a wax, and the surface of the product thus obtained is subjected to surface grinding, lapping, or chemical-mechanical polishing (CMP), and then to remove the wax to thereby attain a predetermined surface roughness and degree of flatness (parallelism).

[0006] However, when there is used a chuck plate which has been obtained as described above by subjecting the surface of the sintered body to surface grinding and lapping, there used to be cases where, even if the application of voltage is stopped at the initial time of putting the chuck plate to a new use, the wafer was not able to be released under the influence of the residual electric charges. This kind of problem can be solved by

repeating the absorption to, and releasing from, the chuck plate several hundred times by using a dummy substrate (i.e., the absorption and releasing of the wafer can be performed well without being subjected to the influence of residual electric charges). This method, however, has a disadvantage in that much time is required for the chuck to function as an electrostatic chuck and that the manufacturing steps increase.

[0007] As a solution, the inventors of this invention have reached a finding, as a result of diligent studies, that the problem of incapability of absorption and releasing of the wafer at the initial time of putting the chuck plate to a new use happens for the following reasons. A description is made of an example in which the chuck plate is made of an aluminum nitride sintered body. The problem in question lies in that the surface of the sintered body suffers from damages by the surface grinding and lapping. Ready-to-be-separated aluminum nitride particles (i.e., particles that could be relatively easily separated or removed out of the combined state) are locally present and, as a result of these aluminum nitride particles becoming an electrically floated state, they function as resistances when the electric charging to the electrodes is stopped. The residual electric charges cannot therefore be discharged, thereby leading to the occurrence of the above-mentioned problem.

[Prior Art Document]

[Patent Document]

[0008] Patent Document 1: JP-A-1989-321136

Patent Document 2: JP-A-2000-21963

[Summary of the Invention]

[Problems to be Solved by the Invention]

[0009] In view of the above points, this invention has a problem of providing a method of manufacturing a chuck plate for use in an electrostatic chuck which has good productivity and is hard of giving rise to

poor releasing of the substrate from the initial time of putting the chuck plate to a new use.

[Means for Solving the Problems]

[0010] In order to solve the above problems, the method according to this invention is a method of manufacturing a chuck plate for use in an electrostatic chuck. The electrostatic chuck comprises: a chuck main body having electrodes; and the chuck plate made of a dielectric body which covers a surface of the chuck main body. The method comprises the steps of: obtaining a sintered body by compression-forming raw material powder into a predetermined shape and then sintering the same; forming, by means of polishing, such a surface of the sintered body as will come into contact with a substrate to be attracted, into a predetermined surface roughness and flatness; and performing blast processing for selectively removing only ready-to-be-separated particles that come into existence on the surface as a result of the above-mentioned polishing.

[0011] According to this invention, by performing blasting after polishing, only the particles that are ready to be-separated and that are brought into existence on the surface as a result of the work of polishing will be selectively removed. As a result, when this kind of chuck plate is assembled into the chuck main body and, from the initial time of putting the chuck plate to a new use as an electrostatic chuck, the to-be-processed substrate, that is the wafer, can be released well without being affected by the residual electric charges when application of voltage to the electrodes has been stopped. In addition, blast processing is performed after polishing in this invention. The working procedure is simple and the productivity can be improved as compared with the conventional method in which the attraction and releasing of the substrate by the chuck plate are repeated several hundreds of times. In addition, in the above-mentioned blasting, the surface roughness and the flatness will not be deteriorated much,

whereby the area of contact with the wafer will not be reduced.

[0012] In this invention, it is preferable to use wet blasting as the blast processing.

[Brief Description of the Drawings]

[0013]

FIG. 1 is a sectional view schematically illustrating an electrostatic chuck in which a chuck plate manufactured by the manufacturing method according to an embodiment of this invention has been assembled.

FIGS. 2(a) to 2(d) schematically illustrate the manufacturing steps by partially enlarging the chuck plate according to this embodiment.

[Embodiments for Carrying Out the Invention]

[0014] With reference to the drawings, a description will now be made of an electrostatic chuck which is provided with a chuck plate that is manufactured according to the manufacturing method of this invention in which, the to-be-processed substrate being defined as a wafer W, in a vacuum processing apparatus for performing processing operations such as a film-forming processing by PVD method, CVD method or the like, a processing operation such as ion implantation processing, etching processing or the like, the wafer W is kept attracted from the initial use and can surely be released after processing operations.

[0015] As shown in FIG. 1, the electrostatic chuck EC is made up of a chuck main body 1 which is disposed at the bottom of the processing chamber (not illustrated), and a chuck plate 2 which is a dielectric body disposed on the upper surface of the chuck main body 1. The chuck main body 1 is made, e.g., of aluminum nitride and an upper portion thereof has built therein positive and negative electrodes 3a, 3b through electrical insulating layers (not illustrated). It is thus so arranged that DC voltage can be applied from a known chuck power supply E.

[0016] In addition, the chuck main body 1 has formed therein a gas

passage 4 which penetrates therethrough in the vertical direction. The lower end of the gas passage 4 is in communication, through a gas pipe 6 having interposed therein a mass-flow controller 5, with a gas source 7 which contains therein an inert gas such as Ar gas or the like. These parts constitute a gas supply means in this embodiment. The chuck main body 1 has built therein a heater 8 of electrical resistance heating type having a known construction so that the wafer W can be heated to, and maintained at, a predetermined temperature.

[0017] The chuck plate 2 is made, e.g., of a sintered body of aluminum nitride, and is made up of: an annular rib portion 2a which is capable of coming into surface contact with an outer peripheral portion on the rear surface of the wafer W; and a plurality of bar-shaped supporting portions 2c which are vertically disposed in a concentric manner in an inner space 2b enclosed by the rib portion 2a. In this case, the height of the supporting portions 2c is set so as to be slightly smaller than the height of the rib portion 2a. It is thus so arranged that the wafer W is supported by each of the supporting portions 2c when the wafer W is absorbed by the front surface of the chuck plate 2.

[0018] After the wafer W has been placed in position on the chuck plate 2, the wafer W will be attracted by the front surface of the chuck plate 2 due to the electrostatic force generated by applying DC voltage between both the electrodes 3a, 3b. At this time, as a result of the surface contact of the outer peripheral portion on the rear surface of the wafer W with the rib portion 2a over the entire circumference of the wafer W, the inner space 2b can be substantially hermetically sealed. By supplying Ar gas through the gas supply means in this state, there is formed in the inner space 2b a gas atmosphere. According to this arrangement, when the heater 8 is operated to heat the wafer W, as a result of forming an inert gas atmosphere in the inner space 2b that is defined by the rib portion 2a and the rear surface of

the wafer W, the wafer W can be heated efficiently by assisting the heat transfer to the wafer W. In this embodiment, a description was made with reference to an example in which only the heater 8 was disposed. Without being limited thereto, an arrangement may also be made to assemble a known cooling means.

[0019] Next, a description will now be made of a method of manufacturing a chuck plate 2 which is a sintered body of aluminum nitride. First, by means of a known method such as a reduction nitriding method or the like, aluminum nitride powder as the raw material (or raw meal) is obtained. Then, after having adequately added to the aluminum nitride powder known organic binders or sintering aids in order to improve the compactibility, the raw material powder is formed by using a known molding machine to thereby manufacture a compact having the above-mentioned shape. Then, the compact thus obtained is sintered in a known sintering furnace in an inert gas atmosphere of 2000 °C to thereby obtain an aluminum nitride sintered body having a desired specific volume resistance. It is to be noted that a so-called hot press sintering method may be used in manufacturing the aluminum nitride sintered body.

[0020] Then, as shown in FIG. 2, out of the surfaces of the thus obtained aluminum nitride body S, the surface coming into contact with the wafer W is subjected to polishing into a predetermined surface roughness and flatness (parallelism). As the polishing, there may be resorted to a surface grinding which uses a diamond grinding stone, lapping machining which uses free abrasive grains, or chemical mechanical polishing (CMP). Machining is thus performed until a predetermined surface roughness (Ra: 0.1 μ m or less) and a flatness (0.005 or less) are attained.

[0021] Here, with reference to FIG. 2, in the above-mentioned aluminum nitride sintered body S, the surface will be damaged on its surface at the time of polishing and, as a result, will become a state in which

aluminum nitride particles g that are ready to be separated or dropped are locally present (see FIG. 2(a)). If this kind of ready-to-be-separated aluminum nitride particles g is present on the surface of contact with the wafer W, the aluminum nitride particles g will become an electrically floating state (see FIG. 2(b)). When the application of voltage to the electrodes 3a, 3b is stopped, the electrically floating state of particles becomes a resistance, whereby the residual electric charges cannot be released (in FIG. 2, the flow of the electric charges are shown in arrows). Therefore, particularly at the initial time of putting the chuck plate 2 to a new use, there is a possibility that the poor detaching or releasing of the wafer will frequently occur.

[0022] As a solution, in this embodiment, there is performed a blast processing. In this blast processing, only the ready-to-be-separated aluminum nitride particles g that are present on the surface of contact, with the wafer W, of the chuck plate 2 which is the aluminum nitride sintered body S are selectively removed (see FIG. 2(c)). As this kind of blast processing, so-called wet blasting is most suitable in which water mixed with grinding particles is simultaneously blasted with air toward the object to be processed, i.e., the chuck plate 2, whereby the surface of the object to be processed is polished.

[0023] As the grinding particles to be used in wet blasting, there are used particles which are made of alumina and the particle size of which is in a range below an average particle size of the sintered alumina. The grinding particles are mixed with water in a predetermined weight ratio. In addition, it is preferable to set the water pressure in the blast processing to 0.01 to 0.05 MPa, and the compressed air pressure to 0.1 to 0.3 MPa. If the water pressure and the air pressure are below the above pressures, it becomes impossible to remove the particles whose adhesion strength among the particles has been lowered. On the other hand, if the water pressure

and the air pressure are above the above-mentioned pressures, there will be a disadvantage in that the surface roughness becomes deteriorated and that the particles whose adhesion strength among the particles has been lowered cannot be removed.

[0024] As described above, by further performing wet blast processing after having performed the polishing, only the ready-to-be-separated aluminum nitride particles g that made their appearance on the surface accompanied by polishing can be selectively removed. Therefore, in case the chuck plate 2 that was manufactured by the manufacturing method according to this embodiment is assembled to the above-mentioned chuck main body 1 to thereby put the product as the electrostatic chuck EC, voltage can be applied to the positive and the negative electrodes 3a, 3b from the beginning through the chuck power supply E. After having attracted the wafer W by a predetermined attraction power and, thereafter, when the power application is stopped, the wafer W can be released well without being influenced by the effect of the residual electric charges (see FIG. 2(d)). In addition, since blast processing is performed after polishing, the work is simple and the productivity can be enhanced as compared with the conventional method in which attraction and releasing of the wafer W by means of the chuck plate 2 are repeated several hundred times. Further, in the above-mentioned blast processing, the surface roughness and the flatness on the surface of the chuck plate 2 show little or no deterioration, and there is no possibility of reduction in the area of contact with the wafer W.

[0025] In order to show the above-mentioned effect, there was manufactured by a known method an aluminum nitride sintered body having the embodiment as described above. Then, the surface of contact with the wafer W was mirror-finished to a surface roughness of $0.1\ \mu\text{m}$. Thereafter, there was performed the wet blast processing.

[0026] Then, the chuck plate 2 was assembled into the chuck main body 1 to constitute the electrostatic chuck EC. The wafer W was set in position on the stage which is provided with a plurality of known lift pins to lift the wafer W to a position right above the electrostatic chuck EC. After having placed the wafer W on the chuck plate 2, the wafer was attracted by a voltage in the range of 0 to 1000 V by the chuck power supply E. Then, by stopping the voltage charging from the chuck power supply E, the lift mechanism was operated. It was then confirmed that the wafer W was lifted by the lift pins without giving rise to poor releasing.

[0027] Although a description has so far been made of this embodiment, without being limited to the above-mentioned constitution, this invention may also be applied to the case in which the chuck plate is made of other materials such as a silicon nitride sintered body or the like. In addition, a description has so far been made of an example in which wet blast processing was employed. However, another blasting method may similarly be applied as long as only the ready-to-be-separated particles can be selectively removed in a simple method.

[Description of Reference Numerals and Characters]

[0028]

EC	electrostatic chuck
1	chuck main body
2	chuck plate (aluminum nitride sintered body S)
2a	rib portion
2b	inner space
2c	supporting portion
3a, 3b	electrodes
g	ready-to-be-separated AlN particles
W	wafer

WHAT IS CLAIMED IS:

1. A method of manufacturing a chuck plate for use in an electrostatic chuck, the electrostatic chuck comprising: a chuck main body having electrodes; and the chuck plate made of a dielectric body which covers a surface of the chuck main body, the method comprising the steps of:

obtaining a sintered body by compression-forming raw material powder into a predetermined shape and then sintering the same;

forming, by means of polishing, such a surface of the sintered body as will come into contact with a substrate to be attracted, into a predetermined surface roughness and flatness; and

performing blast processing for selectively removing only ready-to-be-separated particles that come into existence on the surface as a result of the above-mentioned polishing.

2. The method according to claim 1, wherein the blast processing is wet blasting.