METHOD OF FABRICATING SEMICONDUCTOR DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2015-177931; filed on September 09, 2015; the entire contents of which are incorporated herein by reference.

FIELD

Embodiments described herein relate generally to a method of fabricating a semiconductor device.

BACKGROUND

There is a method of fabricating a thin semiconductor device by bonding a supporting substrate to a surface of a device substrate side on which semiconductor devices are formed, and by thinning a rear surface side of the device substrate in a state of being supported by the supporting substrate by grinding.

Here, stress occurs inside the device substrate due to a structure of a semiconductor device. If the device substrate is thinned by grinding, the device substrate is warped by the stress together with the supporting substrate after a grinding process, and thereby subsequent fabricating processes or a transport process may not be normally performed.

An example of related art includes JP-A-2006-114847.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is an explanatory view illustrating an example of a device substrate which is used for a method of fabricating a semiconductor device according to an embodiment.

FIGS. 2A to 2C are explanatory views illustrating a cross section of a fabricating process of the semiconductor device according to the embodiment.

FIGS. 3A to 3C are explanatory views illustrating a cross section of the fabricating process of the semiconductor device according to the embodiment.

FIGS. 4A and 4B are explanatory views illustrating a cross section of another fabricating process of the semiconductor device according to the embodiment.

FIGS. 5A and 5B are explanatory views illustrating a cross section of another fabricating process of the semiconductor device according to the embodiment.

DETAILED DESCRIPTION

[0005]One embodiment is to provide a method of fabricating a semiconductor device which can normally perform processes after grinding by preventing warpage from being generated after a device substrate is bonded to a supporting substrate and is ground.

[0006]According to one embodiment, a method of fabricating a semiconductor device is provided. The method of fabricating the semiconductor device according to the embodiment includes three processes of an installation process, a bonding process, and a thinning process. In the installation process, a mitigation layer which mitigates warpage of the device substrate that is thinned by grinding is provided on the supporting substrate. In the bonding process, the device substrate is bonded to the supporting substrate on which the mitigation layer is provided. In the thinning process, the device substrate which is supported by the supporting substrate is thinned by grinding.

[0008]A method of fabricating a semiconductor device according to the embodiment will be hereinafter described in detail with reference to the accompanying drawings. In addition, the invention is not limited to the embodiment.

[0009]FIG. 1 is an explanatory view illustrating an example of a device substrate which is used for a method of fabricating a semiconductor device according to an embodiment. In the following embodiment, a process in which a device substrate 10 including semiconductor devices 11 on a surface side thereof is prepared, the device substrate 10 is bonded to a supporting substrate which is not illustrated, and the device substrate 10 which is supported by the supporting substrate is thinned from a rear side thereof, as illustrated in FIG. 1, will be described.

[0010]In addition, the device substrate 10 which is used in the embodiment is, for example, a silicon wafer or the like having a substantially circular plate shape, and both a front surface and a rear surface of a peripheral portion of the device substrate 10 are inclined to the inside.

[0011]For this reason, in the device substrate 10, stress occurs in the inside thereof due to a structure of the semiconductor device 11. If the device substrate is thinned by grinding, the device substrate is warped by the stress together with the supporting substrate after a grinding process.

[0012]Specifically, in the device substrate 10, stress occurs in the device substrate 10 due to stress that a semiconductor layer has, wires, a protection layer, or the like that are included in the semiconductor device 11, and the device substrate 10 is warped by the stress together with the supporting substrate after the grinding process.

[0013]More specifically, in a case where the semiconductor device 11 includes a protection layer having, for example, tensile stress, the thinned device substrate 10 is warped in a downwardly projected arc shape by the stress which compresses the protection layer to the inside in an in-plane direction.

[0014]In contrast to this, in a case where the semiconductor device 11 includes a protection layer having, for example, compression stress, the thinned device substrate 10 is warped in an upwardly projected arc shape by the stress which expands the protection layer to the outside in an in-plane direction.

[0015]Hence, the method of fabricating a semiconductor device according to the embodiment provides a mitigation layer which mitigates warpage of the device substrate 10 which is thinned by grinding, in the supporting substrate which supports the device substrate 10. Hereinafter, the method of fabricating the semiconductor device will be described with reference to FIGS. 2A to 2C and FIGS. 3A to 3C.

[0016]In addition, hereinafter, a case where the device substrate 10 includes a protection layer having stress on a surface of the semiconductor device 11 is used as an example, but the stress occurring inside the thinned device substrate 10 is not limited to the stress that the protection layer has.

[0017]FIGS. 2A to 2C and FIGS. 3A to 3C are explanatory views illustrating cross sections of fabricating processes of the semiconductor device according to the embodiment. The device substrate 10 illustrated in FIGS. 2A to 2C and FIGS. 3A to 3C is a sectional portion taken along line A-A’ of the device substrate 10 illustrated in FIG. 1. In the method of fabricating the semiconductor device according to the embodiment, the device substrate 10 and a supporting substrate 20 are first prepared.

[0018]As illustrated in FIG. 2A, the device substrate 10 includes a protection layer 12 which protects a surface of the semiconductor device 11 that is formed in a device region on the surface. The protection layer 12 is a lamination layer which is formed by laminating a polyimide film, an epoxy film, a phenol-based resin layer, a silicon oxide film, a silicon nitride film, or one of these.

[0019]The aforementioned protection layer 12 has tensile stress or compression stress by physical property of a film. For example, a polyimide film is a film mainly having tensile stress, and in a case where the film is formed on the semiconductor device 11, the polyimide film is compressed toward the inside in an in-plane direction in the device substrate 10. Hence, in a case where the rear surface of the device substrate 10 is grinded to be thinned, the device substrate 10 is warped in a downwardly projected arc shape by the stress which compresses the device substrate 10.

[0020]In addition, the aforementioned lamination layer has tensile stress or compression stress according to mitigation of stress of each film to be laminated. For example, in a case where the sum of stress in the lamination film is compression stress, the lamination film which is formed on the surface of the semiconductor device 11 is expanded toward the outside in an in-plane direction in the device substrate 10. Thus, in a case where the device substrate 10 is thinned by grinding a rear surface thereof, the device substrate 10 is warped in an upwardly projected arc shape by the stress which expands the device substrate 10.

[0021]Meanwhile, as illustrated in FIG. 2B, the supporting substrate 20 uses glass, silicon, or the like, and has a circular plate shape whose diameter and thickness are substantially the same as those of the device substrate 10. In addition, a material and a shape, such as a diameter or a thickness, of the supporting substrate 20 are not limited to these.

[0022]In addition, the supporting substrate 20 includes an oxide film 21 which is a mitigation film which mitigates warpage of the device substrate 10 that is thinned by grinding on a surface thereof. The oxide film 21 is formed on a surface of the supporting substrate 20 by using a plasma chemical vapor deposition (CVD) method.

[0023]In the present embodiment, a thickness of the oxide film 21 is thinned by grinding a rear surface of the device substrate 10 which includes the protection layer 12 on a surface side thereof to a desired thickness, and is set according to the amount of warpage of the supporting substrate 20 which occurs in a case where the thinned device substrate 10 is supported by bonding.

[0024]After the device substrate 10 and the supporting substrate 20 are prepared, an adhesive 30 is formed on a surface of the oxide film 21 which is formed on a surface of the supporting substrate 20, using a spin coat method or the like, as illustrated in FIG. 2C. For example, an organic adhesive or the like such as a urethane-based resin or an epoxy resin is used as the adhesive 30.

[0025]Subsequently, as illustrated in FIG. 3A, a surface of the device substrate 10 whose front and rear surfaces are inverted to each other is bonded to the supporting substrate 20 through the adhesive 30. Thus, the device substrate 10 is thinned to a predetermined thickness by grinding the rear surface of the device substrate 10 using a grinder 4, as illustrated in FIG. 3B.

[0026]As illustrated in FIG. 3C, in a case where the protection layer 12 formed on the surface of the semiconductor device 11 is the protection layer 12 having tensile stress, the thinned device substrate 10 is warped in a downwardly projected arc shape by the stress which is compressed to the inside in an in-plane direction indicated by a white arrow.

[0027]Meanwhile, the supporting substrate 20 includes the oxide film 21 having compression stress on the surface of the supporting substrate 20 in order to mitigate the warpage of the thinned device substrate 10, in this example. For this reason, the supporting substrate 20 is warped in an upwardly projected arc shape by the stress which is expanded to the outside in an in-plane direction indicated by a black arrow illustrated in FIG. 3C.

[0028]Here, surfaces of the device substrate 10 and the supporting substrate 20 are uniformly bonded together through the adhesive 30. Hence, in the device substrate 10 and the supporting substrate 20 which are bonded together, stress which compresses the device substrate 10 and stress which expands the supporting substrate 20 are offset, and thereby the warpage of the thinned device substrate 10 is reduced.

[0029]That is, in the embodiment, the oxide film 21 which is formed on the surface of the supporting substrate 20 makes stress occur in the supporting substrate 20, and thereby the warpage of the device substrate 10 is mitigated. Accordingly, the warpage of the supporting substrate 20 which supports the thinned device substrate 10 that are bonded to the supporting substrate is prevented.

[0030]In addition, after the device substrate 10 is thinned, a post-process such as a process in which the device substrate 10 is peeled off from the supporting substrate 20 and the device substrate 10 is divided into multiple chips, is performed.

[0031]As described above, the method of fabricating the semiconductor device according to the present embodiment includes three processes of an installation process, a bonding process, and a thinning process. In the installation process, the oxide film 21 which mitigates the warpage of the device substrate 10 that is thinned by grinding is provided on the supporting substrate 20. In the bonding process, the device substrate 10 is bonded to the supporting substrate 20 on which the oxide film 21 is provided. In the thinning process, the device substrate 10 which is supported by the supporting substrate 20 is thinned by grinding.

[0032]By doing so, it is possible to prevent warpage of the device substrate 10 and the supporting substrate 20 from increasing, in the method of fabricating the semiconductor device according to the present embodiment. Hence, in the present embodiment, the warpage of the device substrate 10 and the supporting substrate 20 after the grinding process is prevented from increasing, and thus, it is possible to normally perform, for example, transport of the supporting substrate 20 performed by a transport arm before the thinned device substrate 10 is peeled off, mounting the supporting substrate 20 on a flat chuck, or the like.

[0033]In addition, in the present embodiment, the mitigation layer which mitigates the warpage of the device substrate 10 which is thinned by grinding is provided in the supporting substrate 20, and thus, it is not necessary to modify a structure of the semiconductor device 11, such that warpage does not occur in the device substrate 10 whose device substrate 10 side is thinned. That is, in the present embodiment, a thickness of the oxide film 21 which is formed on the surface of the supporting substrate 20 is adjusted, and thus, it is possible to prevent the warpage of the thinned device substrate 10 from occurring.

[0034]In addition, in the form, the oxide film 21 is formed so as to cover the surface of the supporting substrate 20, and thus, the oxide film 21 has the same stress direction. However, the stress direction of the stress that the oxide film 21 has may differ depending on the region in which the oxide film 21 is formed.

[0035]Specifically, after the oxide film 21 is formed on the surface of the supporting substrate 20, etching is performed by using a resist having a predetermined pattern as a mask, and thereby the predetermined pattern is formed in the oxide film 21. By doing so, it is possible for the oxide film 21 to have different stress on a per region basis.

[0036]Hence, by providing the oxide film 21 having a predetermined pattern on the surface of the supporting substrate 20, the warpage of the supporting substrate 20 can be finely adjusted.

[0037]In addition, the oxide film 21 can be easily peeled off from the surface of the supporting substrate 20, and thus, the supporting substrate 20 from which the device substrate 10 is peeled off can be used by recycling.

[0038]In addition, the surface of the supporting substrate 20 is covered by the oxide film 21, and thus, it is possible to prevent the surface of the supporting substrate 20 from being physically damaged when the device substrate 10 is peeled off from the supporting substrate 20.

[0039]In addition, the oxide film 21 with strong adhesion is used for the supporting substrate 20, and thus, stress can easily occur in the supporting substrate 20 according to the stress that the oxide film 21 has.

[0040]In addition, the oxide film 21 with strong adhesion to the adhesive 30 is used, and thus, the oxide film 21 can easily bond the device substrate 10 to the supporting substrate 20.

[0041]In addition, in the form, the oxide film 21 is provided on the surface of the supporting substrate 20, but the location of the oxide film 21 is not limited to the surface of the supporting substrate 20. As another aspect, an oxide film 21a which mitigates stress of the thinned device substrate 10 may be provided on a rear surface of the supporting substrate 20, as illustrated in FIG. 4A.

[0042]As described above, it is possible to prevent the warpage of the device substrate 10 and the supporting substrate 20 from increasing during a grinding process, also in the form.

[0043]In addition, in the form, the oxide film 21a is provided on the rear surface of the supporting substrate 20, and thus, it is possible to prevent the oxide film 21a from being damaged by pressing when the device substrate 10 is bonded to the surface of the supporting substrate 20.

[0044]In addition, oxide films 21 and 21b may be provided on both the front surface and the rear surface of the supporting substrate 20, as illustrated in FIG. 4B. In the form, the oxide film 21 having a thickness greater than that of a rear side surface is provided on a front side surface of the supporting substrate 20 on which the device substrate 10 is bonded.

[0045]In an installation process of the oxide films 21 and 21b on the front surface of the supporting substrate 20 having the form, the oxide film 21 having a predetermined thickness is formed on the front side surface of the supporting substrate 20, and thereafter, the oxide film 21b having a thickness smaller than that of the front side surface is formed on the rear side surface of the supporting substrate 20. Hence, it is possible to adjust the stress of the supporting substrate 20 by forming the oxide film 21b on the front side surface of the supporting substrate 20.

[0046]In addition, in the aforementioned embodiment, the adhesive 30 is used for bonding the device substrate 10 to the supporting substrate 20, but the device substrate 10 may be directly bonded to the supporting substrate 20. In this case, the oxide film 21 which is provided on the front surface of the supporting substrate 20 may be used as the oxide film 21 with adhesion, and the device substrate 10 adheres to the supporting substrate 20 by the oxide film 21.

[0047]Next, another method of fabricating the semiconductor device according to the present embodiment will be described. In the embodiment, a mitigation layer which mitigates warpage of a device substrate that is thinned by grinding is provided on a front layer or a front surface of a supporting substrate.

[0048]In addition, in the method of fabricating the semiconductor device, the semiconductor device is fabricated through the same processes, except for the process illustrated in FIG. 2B among the processes illustrated in FIGS. 2A to 2C and FIGS. 3A to 3C described above. In the following embodiment, a different process will be described with reference to FIGS. 5A and 5B. FIGS. 5A and 5B are explanatory views illustrating a cross section of another fabricating process of the semiconductor device according to the embodiment.

[0049]As illustrated in FIG. 5A, the supporting substrate 20 includes an impurity layer 22 which is a mitigation layer that mitigates warpage of the device substrate 10 thinned by grinding, on a front side surface on which the device substrate 10 is bonded. The impurity layer 22 is formed by doping impurity such as boron (B), phosphorus (P), or arsenic (As). For example, an ion injecting method or the like is used for a doping method.

[0050]In the supporting substrate 20, impurity is doped onto the front side surface. Thereby, impurity concentration of the front side surface increases, stress occurs so as to expand the supporting substrate to the outside in an in-plane direction, and the supporting substrate 20 is warped in an upwardly projected arc shape. For example, the supporting substrate 20 is used in a case where the supporting substrate supports the device substrate 10 including the protection layer 12 which has tensile stress and is formed on the surface of the semiconductor device 11.

[0051]In addition, the device substrate 10 may be bonded to the rear side surface of the supporting substrate 20 whose front and rear surfaces are inverted to each other. The supporting substrate 20 is warped in a downwardly projected arc shape, and thus, the supporting substrate is used in a case where the supporting substrate supports the device substrate 10 including the protection layer 12 which has compression stress and is formed on the front surface of semiconductor device 11.

[0052]Hence, in the form, the impurity layer 22 which is provided on the front side layer of the supporting substrate 20 makes stress occur in the supporting substrate 20, and the supporting substrate 20 in which stress occurs mitigates the warpage which is generated in the device substrate 10.

[0053]In addition, in the embodiment, the doping amount of impurities with respect to the supporting substrate 20 is set according to the amount of warpage of the supporting substrate 20 which is generated in a case where the rear side of the device substrate 10 including the protection layer 12 on a surface thereof is ground to a predetermined thickness to be thinned, and the thinned device substrate 10 is bonded to be supported.

[0054]Also in the method of fabricating the aforementioned semiconductor device, it is possible to prevent the warpage of the device substrate 10 and the supporting substrate 20 in the grinding process from increasing.

[0055]In addition, as illustrated in FIG. 5B, the supporting substrate 20 includes a roughness portion 23 which is a mitigation layer that mitigates warpage of the device substrate 10 on a front side surface to which the device substrate 10 is bonded, as another form. The roughness portion 23 is formed by thinning the front surface of the supporting substrate 20, using plasma etching.

[0056]As the front surface of the supporting substrate 20 is thinned and becomes rough, stress occurs so as to expand the supporting substrate to the outside in an in-plane direction, and thereby the supporting substrate 20 is warped in a upwardly projected arc shape. For example, the supporting substrate 20 is used in a case where the supporting substrate supports the device substrate 10 including the protection layer 12 which has tensile stress and is formed on the surface of the semiconductor device 11.

[0057]In addition, the device substrate 10 may be bonded to the rear side surface of the supporting substrate 20 whose front and rear surfaces are inverted to each other. The supporting substrate 20 is warped in a downwardly projected arc shape, and thus, the supporting substrate is used in a case where the supporting substrate supports the device substrate 10 including the protection layer 12 which has compression stress and is formed on the front surface of semiconductor device 11.

[0058]Hence, in the form, the roughness portion 23 which is formed on the front side surface of the supporting substrate 20 makes stress occur in the supporting substrate 20, and the supporting substrate 20 in which stress occurs mitigates the warpage which is generated in the device substrate 10.

[0059]In addition, in the embodiment, the roughening amount of the front surface of the supporting substrate 20 is set according to the amount of warpage of the supporting substrate 20 which is generated in a case where the rear side of the device substrate 10 including the protection layer 12 on a surface thereof is ground to a predetermined thickness to be thinned, and the thinned device substrate 10 is bonded to be supported.

[0060]Also in the method of fabricating the aforementioned semiconductor device, it is possible to prevent the warpage of the device substrate 10 and the supporting substrate 20 in the grinding process from increasing.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

WHAT IS CLAIMED IS:

1. A method of fabricating a semiconductor device comprising:

providing a mitigation layer which mitigates warpage of a device substrate that is thinned by grinding on a supporting substrate;

bonding the device substrate to the supporting substrate on which the mitigation layer is provided; and

thinning the device substrate which is supported by the supporting substrate by grinding.

2. The method according to Claim 1, wherein the providing the mitigation layer on the supporting substrate includes forming a chemical vapor deposition (CVD) film on a surface of the supporting substrate.

3. The method according to Claim 2, wherein the forming the CVD film includes forming a CVD film having a thickness greater than that of a rear side surface on a front side surface of the supporting substrate to which the device substrate is bonded.

4. The method according to Claim 1, wherein the providing the mitigation layer on the supporting substrate includes doping impurities onto a surface layer of the supporting substrate.

5. The method according to Claim 1, wherein providing the mitigation layer on the supporting substrate includes forming roughness portion on a surface of the supporting substrate.

ABSTRACT

According to one embodiment, a method of fabricating a semiconductor device is provided. The method of fabricating the semiconductor device according to the embodiment includes three processes of an installation process, a bonding process, and a thinning process. In the installation process, a mitigation layer which mitigates warpage of the device substrate that is thinned by grinding is provided on the supporting substrate. In the bonding process, the device substrate is bonded to the supporting substrate on which the mitigation layer is provided. In the thinning process, the device substrate which is supported by the supporting substrate is thinned by grinding.

Drawings

FIG. 2B

PLASMA CVD

FIG. 5A

ION INJECTION

FIG. 5B

PLASMA ETCHING