R-face sapphire, and CG silicon process involving growth of non-single-crystal silicon on glass and subsequent laser annealing to improve crystallinity have been developed, allegedly none of them surpass the bonding process.

[0004]

It is noted that bonded wafers of heterogeneous materials (e.g., SOQ, SOS and SOG) leave concerns about defects induced during the process. Specifically, typical device processes involve heat treatment at a high temperature in excess of 850°C to form a gate oxide film. In these bonded substrates of heterogeneous materials, hereinafter referred to as "heterogeneous composite substrates," such high-temperature process applies strong compressive/tensile stresses to the silicon thin film to form various defects such as micro-cracks. The cause originating from the heterogeneous composite substrate is a substantial difference in coefficient of expansion between the support substrate known as "handle substrate" and the upper layer or silicon thin film. This is the essential problem of heterogeneous composite substrates.

SUMMARY OF INVENTION

Technical Problem

[0005]

~~An object~~Embodiments of the invention~~, which has been made under the above-mentioned circumstances, is~~ seek to provide a thermally oxidized heterogeneous composite substrate having a minimized number of micro-cracks and other defects left after high-temperature treatment in excess of 850°C to form an oxide layer, and a method for manufacturing the same.

Solution to Problem

[0006]

Making extensive investigations to attain the above objects, the inventors have found that better results ~~are~~ may be obtained when a transparent insulating wafer (quartz, glass, sapphire or the like) having a silicon thin film transferred thereon is subjected to heat treatment, which may be referred

to as previous heat treatment, prior to high-temperature treatment in excess of 850°C, and the temperature of the previous heat treatment ranges from 650°C to 850°C.

[0007]

Specifically, the previous heat treatment is a treatment at 650°C to 850°C for reducing defects which are otherwise formed during high-temperature treatment in excess of 850°C. The previous heat treatment is also regarded as a treatment for averaging localized stresses over the entire wafer surface. It is estimated that the localized stresses are caused by material strains and density gradation of the handle substrate, in-plane non-uniformity of the bonding process and the like.

Also, the previous heat treatment is a treatment for increasing the bond strength at the bonding interface to a sufficient level before the high-temperature treatment temperature is reached, for thereby preventing the silicon thin film from peeling or shifting when strong stresses are applied thereto.

High-temperature treatment, typically oxidative treatment is carried out subsequent to the previous heat treatment, with this sequence being effective for reducing the number of defects left after oxidation.

[0008]

Accordingly, aspects of the present invention provide~~s~~ a thermally oxidized heterogeneous composite substrate and a method for manufacturing the same, as defined below.

~~[1] A~~ A first aspect of the invention provides a thermally oxidized heterogeneous composite substrate, obtained by subjecting a heterogeneous composite substrate comprising a single crystal silicon film on a handle substrate to previous heat treatment at 650 to 850°C prior to thermal oxidative treatment at a temperature in excess of 850°C, and thereafter conducting thermal oxidative treatment at a temperature in excess of 850°C.

~~[2] The thermally oxidized heterogeneous composite substrate of [1] wherein~~ Preferably, the handle substrate is made of glass, quartz or sapphire.

~~[3] The thermally oxidized heterogeneous composite substrate of [1] or [2] wherein~~ Preferably, a buried oxide layer intervenes between the handle substrate and the single crystal silicon film.

~~[4] The thermally oxidized heterogeneous composite substrate of any one of [1] to [3] wherein~~Preferably, the previous heat treatment is conducted in an atmosphere of argon, nitrogen, oxygen, hydrogen, helium or a mixture of an inert gas and oxygen.

~~[5] The thermally oxidized heterogeneous composite substrate of any one of [1] to [4] wherein~~ Preferably, the handle substrate has a coefficient of thermal expansion of 0.54 to 7.4 ppm at 400°C or lower.

~~[6] The thermally oxidized heterogeneous composite substrate of [5] wherein~~Preferably, the handle substrate is made of sapphire, a sapphire wafer having a coefficient of expansion of up to 7.4 ppm at room temperature to 400°C.

~~[7] A~~ A second aspect of the invention provides a method for manufacturing a thermally oxidized heterogeneous composite substrate, comprising the steps of subjecting a heterogeneous composite substrate comprising a single crystal silicon film on a handle substrate to previous heat treatment at 650 to 850°C, and thereafter conducting thermal oxidative treatment at a temperature in excess of 850°C.

~~[8] A method for manufacturing a thermally oxidized heterogeneous composite substrate according to [7] wherein~~Preferably, the handle substrate is made of glass, quartz or sapphire.

~~[9] A method for manufacturing a thermally oxidized heterogeneous composite substrate according to [7] or [8] wherein~~Preferably, the heterogeneous composite substrate comprises a buried oxide layer disposed between the handle substrate and the single crystal silicon film.

~~[10] A method for manufacturing a thermally oxidized heterogeneous composite substrate according to any one of [7] to [9] wherein~~Preferably, the previous heat treatment is conducted in an atmosphere of argon, nitrogen, oxygen, hydrogen, helium or a mixture of an inert gas and oxygen.

~~[11] A method for manufacturing a thermally oxidized heterogeneous composite substrate according to any one of [7]~~

~~to [10] wherein~~Preferably, the handle substrate has a coefficient of thermal expansion of 0.54 to 7.4 ppm at 400°C or lower.

~~[12] A method for manufacturing a thermally oxidized heterogeneous composite substrate according to [11] wherein~~Preferably, the handle substrate is made of sapphire, a sapphire wafer having a coefficient of expansion of up to 7.4 ppm at room temperature to 400°C.

Advantageous Effects of Invention

[0009]

According to embodiments of the invention, a thermally oxidized heterogeneous composite substrate having a minimized number of defects after thermal oxidation is available.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

FIG. 1 is a graph plotting the number of HF defects in thermally oxidized SOS wafer substrates when previous heat treatment is conducted at varying temperatures.

FIG. 2 is a graph plotting the number of HF defects in thermally oxidized SOQ wafer substrates when previous heat treatment is conducted at varying temperatures.

FIG. 3 is a graph plotting the number of HF defects in thermally oxidized SOS wafer substrates when previous heat treatment is conducted on SOS wafers having a single crystal silicon film in varying sapphire orientations.

DESCRIPTION OF EMBODIMENTS

[0011]

According to the invention, a thermally oxidized heterogeneous composite substrate is obtained by subjecting a heterogeneous composite substrate comprising a single crystal silicon film on a handle substrate to previous heat treatment at 650 to 850°C, and thereafter conducting thermal oxidative treatment at a temperature in excess of 850°C.

Herein, a buried oxide (BOX) layer may intervene between the handle substrate and the single crystal silicon film.