DESCRIPTION

SUBSTRATE PROCESSING METHOD AND SUBSTRATE PROCESSING APPARATUS

TECHNICAL FIELD

[0001] The various aspects and exemplary embodiments described herein pertain generally to a substrate processing method and a substrate processing apparatus.

BACKGROUND

[0002] Patent Document 1 discloses a method of manufacturing a semiconductor device. The method of manufacturing the semiconductor device includes a heating process of radiating a CO_2 laser from a rear surface of a semiconductor substrate to locally heat a separation oxide film, and a transfer process of causing separation in the separation oxide film and/or at the interface between the separation oxide film and the semiconductor substrate to transfer a semiconductor device to a transfer destination substrate.

PRIOR ART DOCUMENT

[0003] Patent Document 1: Japanese Patent Laid-open Publication No. 2007-220749

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004] In view of the foregoing, in a combined substrate in which a first substrate and a second substrate are bonded to each other, a device layer formed on a surface of the second substrate is appropriately transferred to the first substrate.

MEANS FOR SOLVING THE PROBLEMS

[0005] In one exemplary embodiment, there is provided a method of transferring, in a combined substrate in which a first substrate and a second substrate are bonded to each other, a device layer formed on a surface of the second substrate to the first substrate. A laser beam is radiated in a pulse shape from a rear surface side of the second substrate to a laser absorption layer formed between the second substrate and the device layer.

EFFECTS OF THE INVENTION

[0006] According to the present disclosure, in the combined substrate in which the first substrate and the second substrate are bonded to each other, the device layer formed on the surface of the second substrate can be appropriately transferred to the first substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] **FIG. 1** is an explanatory diagram comparing a power of a laser beam when a pulse wave and a continuous wave are used.

FIG. 2 is a side view schematically illustrating a configuration of a combined wafer to be processed in a wafer processing system.

FIG. 3 is a plan view schematically illustrating a configuration of the wafer processing system.

FIG. 15 is a side view schematically illustrating a configuration of a laser radiation device according to another exemplary embodiment.

FIG. 16 is a plan view schematically illustrating the configuration of the laser radiation device according to another exemplary embodiment.

FIG. 17 is an explanatory diagram illustrating that a laser beam is radiated to a laser absorption layer according to another exemplary embodiment.

FIG. 18 is an explanatory diagram illustrating that a laser beam is radiated to the laser absorption layer according to another exemplary embodiment.

FIG. 19 is an explanatory diagram illustrating that a laser beam is radiated to the laser absorption layer according to another exemplary embodiment.

FIG. 20 is a side view schematically illustrating a configuration of a laser radiation device according to another exemplary embodiment.

FIG. 21 is a side view schematically illustrating a configuration of a guide unit.

FIG. 22 is a side view schematically illustrating a configuration of a holding member.

FIG. 23 is a plan view schematically illustrating the configuration of the guide unit and the holding member.

FIG. 24A and **FIG. 24B** are explanatory diagrams illustrating that a device layer formed on a surface of a second wafer is transferred to a first wafer according to another exemplary embodiment.

FIG. 25A to **FIG. 25E** are explanatory diagrams illustrating that the device layer formed on the surface of the second wafer is transferred to the first wafer according to another exemplary embodiment.

FIG. 26A to **FIG. 26E** are explanatory diagrams illustrating that the device layer formed on the surface of the second wafer is transferred to the first wafer according to another exemplary embodiment.

FIG. 27A to **FIG. 27E** are explanatory diagrams illustrating that the device layer formed on the surface of the second wafer is transferred to the first wafer according to another exemplary embodiment.

FIG. 28A to **FIG. 28D** are explanatory diagrams illustrating that the device layer formed on the surface of the second wafer is transferred to the first wafer according to another exemplary embodiment.

FIG. 29 is a side view schematically illustrating a configuration of a combined wafer according to another exemplary embodiment.

DETAILED DESCRIPTION

[0008] Recently, in a manufacturing process of LEDs, a so-called laser lift-off processing is performed in which a GaN (gallium nitride)-based compound crystal layer (material layer) is separated from a sapphire substrate using a laser beam. The reason for performing the laser lift-off processing is as follows. Since the sapphire substrate has transmittance to a short wavelength laser beam (for example, UV light), a short wavelength laser beam having a high absorptivity for an absorption layer can be used. Therefore, a wide choice of laser beams can be allowed.

[0009] Meanwhile, in a manufacturing process of semiconductor devices, a device layer formed on a surface of one substrate (silicon substrate such as semiconductor) is transferred to another substrate. In general, a silicon substrate has transmittance to a laser beam in the NIR (near infrared) range, and an absorption layer also has transmittance to the laser beam in the NIR range.

considered at all and there is no suggestion thereof. Therefore, the conventional method of transferring the device layer needs to be improved.

[0014] According to the present disclosure, in a combined substrate in which a first substrate and a second substrate are bonded to each other, a device layer formed on a surface of the second substrate is appropriately transferred to the first substrate. Hereinafter, a wafer processing system including a laser radiation device as a substrate processing apparatus and a wafer processing method as a substrate processing method according to the present exemplary embodiment will be described with reference to the drawings. Further, in the present specification and the drawings, substantially the same functional components will be denoted by the same reference numerals and redundant descriptions thereof will be omitted.

[0015] As will be described below, a wafer processing system 1 according to the present exemplary embodiment performs a processing onto a combined wafer T as a combined substrate in which a first wafer W1 as a first substrate and a second wafer W2 as a second substrate are bonded to each other, as shown in **FIG. 2**. Hereinafter, a surface of the first wafer W1 to be bonded to the second wafer W2 will be referred to as a front surface W1a and a surface opposite to the front surface W1a will be referred to as a rear surface W1b. Likewise, a surface of the second wafer W2 to be bonded to the first wafer W1 will be referred to as a front surface W2a and a surface opposite to the front surface W2a will be referred to as a rear surface W2b.

[0016] The first wafer W1 is a semiconductor wafer, for example, such as a silicon substrate. A device layer D1 and a front surface film F1 are stacked on the front surface W1a of the first wafer W1 in this order from the front surface W1a. The device layer D1 includes a plurality of devices. Examples of the front surface film F1 may include an oxide film (SiO_2 film, TEOS film),

an SiC film, an SiCN film or an adhesive. The device layer D1 and the front surface film F1 may not be formed on the front surface W1a.

[0017] The second wafer W2 is also a semiconductor wafer, for example, such as a silicon substrate. A laser absorption layer P, a device layer D2 and a front surface film F2 are stacked on the front surface W2a of the second wafer W2 in this order from the front surface W2a. The laser absorption layer P is configured to absorb a laser beam radiated from a laser radiation unit 110, as will be described later. For example, an oxide film (SiO_2 film) is used as the laser absorption layer P. However, the laser absorption layer P is not particularly limited as long as it absorbs the laser beam. The device layer D2 and the front surface film F2 are the same as the device layer D1 and the front surface film F1, respectively, of the first wafer W1. Further, the front surface film F1 of the first wafer W1 and the front surface film F2 of the second wafer W2 are bonded to each other. The position of the laser absorption layer P is not limited to the above-described exemplary embodiment. For example, the laser absorption layer P may be formed between the device layer D2 and the front surface film F2. The device layer D2 and the front surface film F2 may not be formed on the front surface W2a. In this case, the laser absorption layer P is formed on the first wafer W1 and the device layer D1 of the first wafer W1 is transferred to the second wafer W2.

[0018] As shown in **FIG. 3**, the wafer processing system 1 includes a carry-in/out block 10, a transfer block 20 and a processing block 30 which are connected as one body. The carry-in/out block 10 and the processing block 30 are provided around the transfer block 20. Specifically, the carry-in/out block 10 is provided on a negative Y-axis direction side of the transfer block 20. A laser radiation device 31 of the processing block 30 is provided on a negative X-axis direction side of the transfer block 20 and a cleaning device 32 to be described later is provided on a positive X-axis direction side of the transfer block 20.

[0045] According to the above-described exemplary embodiment, in the laser radiation device 31, the laser beam L is radiated in the pulse shape to the laser absorption layer P. Thus, the peak power of the laser beam L can be increased. As a result, the separation can occur at the interface between the laser absorption layer P and the second wafer W2. Further, when the laser beam L is radiated in the pulse shape, the laser lift-off can be stably performed due to the smaller thermal influence than when the continuous wave is used. Therefore, the second wafer W2 can be appropriately separated from the laser absorption layer P and the device layer D2 can be transferred to the first wafer W1.

[0046] Herein, an interval of radiating the laser beam L, *i.e.*, a pulse interval, is preferably set to be uniform to achieve uniform separation between the first wafer W1 and the second wafer W2 in the surface of the wafer. However, if the chuck 100 (combined wafer T) is rotated, a rotation speed of the chuck 100 increases as the laser beam L moves from the outer side to the inner side in the diametrical direction to make the pulse interval uniform. In this case, when the rotation speed of the chuck 100 reaches an upper limit, an interval between the laser beams L may decrease as the radiation position of the laser beam L moves to the inner side in the diametrical direction. Thus, the laser beams L may overlap with each other at a central portion. Therefore, the interval of radiating the laser beam L needs to be adjusted. For example, there are two methods as follows.

[0047] The first method is to control the rotation speed of the chuck 100. That is, when the radiation position of the laser beam L is on the outer side in the diametrical direction of the laser absorption layer P, the rotation speed is decreased, and when the radiation position of the laser beam L is on the inner side, the rotation speed is increased. The adjustment of the rotation speed is performed depending on the frequency of the laser beam L. In this case, the interval of

WE CLAIM

1. A substrate processing method of transferring, in a combined substrate in which a first substrate and a second substrate are bonded to each other, a device layer formed on the second substrate to the first substrate, in which

a first device layer and a first surface film are formed on the first substrate in this order from a front surface side,

a laser absorption layer, a second device layer, and a second surface film are formed on the second substrate in this order from a front surface side, and

the first substrate and the second substrate have the first surface film and the second surface film bonded to each other,

the method comprising:

radiating a laser beam in a pulse shape from a rear surface side of the second substrate to the laser absorption layer; and

separating the second substrate from the first substrate at an interface between the laser absorption layer and the second substrate, and transferring the second device layer and the second surface film to the first substrate.

2. The substrate processing method of Claim 1, wherein:

the laser beam is radiated from an outer side to an inner side of the laser absorption layer in a diametrical direction; and

the radiation of the laser beam starts from between an outer edge of the second substrate and an outer edge of the laser absorption layer being a bonding edge between the first substrate and the second substrate in the combined substrate.

3. The substrate processing method of Claim 1 or 2, wherein

rotation of the combined substrate and movement of the combined substrate in the diametrical direction are alternately performed, and the laser beam is annularly radiated to the laser absorption layer..

4. The substrate processing method of any one of Claims 1 to 3, wherein

the first substrate from which the second substrate has been separated is cleaned.

5. The substrate processing method of any one of Claims 1 to 4,

wherein

the first substrate from which the second substrate has been separated is etched.

6. The substrate processing method of any one of Claims 1 to 5,

wherein

the first substrate from which the second substrate has been separated is subjected to a CMP processing.

7. The substrate processing method of any one of Claims 1 to 6,

wherein:

the laser beam is radiated while the combined substrate is rotated; and

a rotation speed of the combined substrate is higher when the laser beam is radiated to the inner side of the laser absorption layer in the diametrical direction than when the

laser beam is radiated to the outer side, and a frequency of the laser beam radiated to the outer side of the laser absorption layer in the diametrical direction is higher than a frequency of the laser beam radiated to the inner side.

8. The substrate processing method of any one of Claims 1 to 7,

wherein:

the first surface film is an oxide film; and

the second surface film is an oxide film.

9. A substrate processing apparatus configured to transfer, in a combined substrate in which a first substrate and a second substrate are bonded to each other, a device layer formed on a surface of the second substrate to the first substrate, in which

a first device layer and a first surface film are formed on the first substrate in this order from a front surface side,

a laser absorption layer, a second device layer, and a second surface film are formed on the second substrate in this order from a front surface side, and

the first substrate and the second substrate have the first surface film and the second surface film bonded to each other,

the substrate processing apparatus comprising:

a holder configured to hold a rear surface of the first substrate;

a laser radiation unit configured to radiate a laser beam in a pulse shape from a rear surface side of the second substrate to the laser absorption layer in a state where the holder holds the first substrate;

a rotation mechanism configured to rotate the holder;

a movement mechanism configured to move the holder in a diametrical direction; and

a controller configured to control the rotation mechanism, the movement mechanism, and the laser radiation unit, wherein

the controller alternately performs rotation of the holder and movement of the holder in the diametrical direction, and controls the rotation mechanism, the movement mechanism, and the laser radiation unit to annularly radiate the laser beam to the laser absorption layer.

10. The substrate processing apparatus of Claim 9, wherein

the controller controls the laser radiation unit to radiate the laser beam from an outer side to an inner side of the laser absorption layer in the diametrical direction and start the radiation of the laser beam from between an outer edge of the second substrate and an outer edge of the laser absorption layer being a bonding edge between the first substrate and the second substrate in the combined substrate.

11. A substrate processing system configured to transfer, in a combined substrate in which a first substrate and a second substrate are bonded to each other, a device layer formed on a surface of the second substrate to the first substrate, in which

a first device layer and a first surface film are formed on the first substrate in this order from a front surface side,

a laser absorption layer, a second device layer, and a second surface film are formed on the second substrate in this order from a front surface side, and

the first substrate and the second substrate have the first surface film and the second surface film bonded to each other,

the substrate processing system comprising:

a holder configured to hold a rear surface of the first substrate;

a laser radiation unit configured to radiate a laser beam in a pulse shape from a rear surface side of the second substrate to the laser absorption layer in a state where the holder holds the first substrate; and

a transfer unit configured to separate the second substrate from the first substrate at an interface between the laser absorption layer and the second substrate, and transfer the second device layer and the second surface film to the first substrate.

12. The substrate processing system of Claim 11, further comprising

a cleaning device configured to clean the first substrate from which the second substrate has been separated.

ABSTRACT

A method of transferring, in a combined substrate in which a first substrate and a second substrate are bonded to each other, a device layer formed on a surface of the second substrate to the first substrate is provided. A laser beam is radiated in a pulse shape from a rear surface side of the second substrate to a laser absorption layer formed between the second substrate and the device layer.