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Storage device and control method

Abstract

According to one embodiment, a storage device includes a control apparatus and a stocker. The control apparatus writes data to or reads data from a storage medium that includes a plurality of non-volatile memory chips. The stocker stores a plurality of the storage media that are detached from the control apparatus. The control apparatus includes a first temperature control system. The first temperature control system raises temperature of the storage medium to a first temperature or higher. The stocker includes a second temperature control system. The second temperature control system cools the storage medium to a second temperature or lower. The second temperature is lower than the first temperature.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a Continuation Application of PCT Application No. PCT/JP2019/044931, filed Nov. 15, 2019, the entire contents of which are incorporated herein by reference.

FIELD
(1) Embodiments described herein relate generally to a storage device and a control method.
BACKGROUND
(2) Recently, various storage devices such as a solid state drive (SSD) and a hard disk drive (HDD) have been used. For example, a NAND flash memory mounted on an SSD is manufactured by forming a plurality of NAND flash memories as semiconductor chips on a semiconductor wafer and then dicing them.
(3) Furthermore, a probe card is used as an inspection jig that relays electrical signals between the semiconductor wafer on which the semiconductor chips are formed and an inspection device that inspects the semiconductor chips. In simplified terms, the probe card is includes a printed circuit board PCB and a probe. A prober brings a pad electrode formed on the semiconductor wafer into contact with the probe of the probe card, and, for example, electrically connects a device on the printed circuit board PCB and the semiconductor wafer.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** shows an example of a configuration of a storage device of an embodiment.
(2) FIG. **2** shows a state in which a probe of a probe card is in contact with a pad electrode formed on a wafer in the storage device of the embodiment.
(3) FIG. **3** is a schematic block diagram of the storage device of the embodiment.
(4) FIG. **4** is a diagram for explaining an example of a setting of a temperature control area relating to a stage in the storage device of the embodiment.
(5) FIG. **5** shows an example of a configuration of a heating and cooling system provided in the stage of the storage device of the embodiment.
(6) FIG. **6** shows an example of an arrangement of the heating and cooling system in the stage of the storage device of the embodiment.
(7) FIG. **7** is a diagram for explaining an example of a temperature control by the heating and cooling system provided in the stage in the storage device of the embodiment.
(8) FIG. **8** is a diagram for explaining an example of a mechanism in which a device on the probe card centrally controls the temperature of the prober in the storage device of the embodiment.
(9) FIG. **9** shows a plurality of probes disposed on a first side of the probe card in the storage device of the embodiment.
(10) FIG. **10** shows a plurality of controllers disposed on a second side of the probe card in the storage device of the embodiment.
(11) FIG. **11** is a diagram for explaining an example of an operation of the device implemented on

the prober in the storage device of the embodiment.
(12) FIG. **12** shows a first example of a cooling system provided in a stocker in the storage device of the embodiment.
(13) FIG. **13** shows a second example of the cooling system provided in the stocker in the storage device of the embodiment.
(14) FIG. **14** is a flowchart showing an example of a flow of temperature control during wafer replacement executed in the storage device of the embodiment.
DETAILED DESCRIPTION
(15) Embodiments will be described hereinafter with reference to the accompanying drawings.
(16) In general, according to one embodiment, a storage device includes a control apparatus and a stocker. The control apparatus writes data to or reads data from a storage medium that includes a plurality of non-volatile memory chips. The stocker stores a plurality of the storage media that are detached from the control apparatus. The control apparatus includes a first temperature control system. The first temperature control system raises temperature of the storage medium to a first temperature or higher. The stocker includes a second temperature control system. The second temperature control system cools the storage medium to a second temperature or lower. The second temperature is lower than the first temperature.
(17) FIG. **1** shows an example of a configuration of a storage device **1** of the present embodiment.
(18) In the present embodiment, it is assumed that a probe card, which is an inspection jig, is diverted to build a large-capacity storage device **1** using semiconductor wafers without dicing the wafers. Furthermore, it is assumed that the semiconductor wafers that are electrically connectable to probes can be replaced and that a larger-capacity storage device **1** is built by using multiple semiconductor wafers.
(19) In constructing such a storage device **1**, it is preferable that the temperature of the semiconductor wafers in the prober be kept at high temperature, above room temperature, and the temperature be kept at a uniform temperature within the semiconductor wafer, while the temperature of the semiconductor wafers stored outside the prober be kept at low temperature, below the room temperature.
(20) The storage device **1** includes a reader and writer (prober) **100**, a storage conveyance system **200**, and a stocker **300**. In FIG. **1**, an example where two probers **100** are provided is shown. However, it is not limited thereto, and the number of probers **100** may be changed in various ways. In addition, the storage device **1** includes an air conditioning control system **500** for replacing the atmosphere in the prober **100**, the storage conveyance system **200**, and the stocker **300** with dry air, noble gas, inert gas, or the like that does not contain water.
(21) The storage device **1** is equipped with a semiconductor wafer (wafer **400**), as a storage, on which a plurality of NAND flash memory chips (NAND chips) are formed. The storage device **1** is equipped with a plurality of wafers **400**, and selects and uses a predetermined number of wafers **400** (two wafers **400** in the case of the example shown in FIG. **1**) as appropriate from among the plurality of wafers **400**. Specifically, the storage device **1** can replace the wafer **400** in the prober **100** with the wafer **400** in the stocker **300**.
(22) The prober **100** includes a probe card **110**, a stage **120**, and a drive unit **130**.
(23) The probe card **110** is a unit that electrically connects to the wafer **400** on the stage **120**. As mentioned above, the probe card **110**, in simplified terms, includes a printed circuit board PCB and a probe. In the storage device **1** of the present embodiment, a controller that controls writing of data to the NAND chip and reading of data from the NAND chip formed on the wafer **400**, or the like, is mounted on the printed circuit board PCB of the probe card **110** as a device **111**. In addition, in the storage device **1** of the present embodiment, a temperature control system (a heating and cooling system **112**, a cooling system **113**, and a heat insulating material **114**) is provided in the probe card **110**. The temperature control system provided in the probe card **110** will be described later.
(24) The stage **120** is a unit that holds the wafer **400**. In the storage device **1** of the present

embodiment, a temperature control system (a heating and cooling system **121**) is also provided in the stage **120**. The temperature control system provided in the stage **120** will also be described later.
(25) The drive unit **130** is a unit that moves the stage **120** to bring the probe of the probe card **110** into contact with pad electrodes formed on the wafer **400**. Here, it is assumed that the drive unit **130** moves the stage **120**, but it may also move the probe card **110**. The drive unit **130** may also move both the probe card **110** and the stage **120**. The drive unit **130** may also move the stage **120** so as to pull the probe that is in contact with the pad electrode away from the pad electrode.
(26) FIG. **2** shows a state in which a probe **115** of the probe card **110** is in contact with a pad electrode **410** formed on the wafer **400** by the drive unit **130**.
(27) When the probe **115** comes into contact with the pad electrode **410**, a controller mounted on the printed circuit board PCB of the probe card **11** as one of the devices **111** is electrically connected to the NAND chip that is formed on the wafer **400**. This allows the controller to control writing of data to the NAND chip, reading of data from the NAND chip, and erasing of data in the NAND chip.
(28) Returning to FIG. **1**, the description of a configuration example of the storage device **1** will continue.
(29) The storage conveyance system **200** includes a storage conveyer **210**.
(30) The storage conveyer **210** conveys the wafers **400**, which are the storage in the storage device **1** of the present embodiment, from the stocker **300** to the prober **100**, or from the prober **100** to the stocker **300**. Note that the configuration described below is an example, and the means for conveying the wafers **400** is not limited thereto. The storage conveyer **210** can move in the vertical and horizontal directions. The storage conveyer **210** includes a support **211** that can be rotated with the vertical direction as an axis, and a tray **212** that, for example, has an elongated plate-like shape and is supported by the support **211** at one end so that the other end of the longitudinal direction protrudes in a horizontal direction. In the case of replacing the wafers **400** in the stocker **300**, the storage conveyer **210** first performs operations for conveying wafers **400** from the prober **100** to the stocker **300**. Specifically, the operations are performed by a procedure such as (1) moving the tray **212** in the vertical direction so that the height becomes a suitable height for taking out the wafer **400** in the prober **100**, (2) rotating the tray **212** to face the prober **100** side, (3) moving the tray **212** in the horizontal direction toward the prober **100** side to hold the wafer **400** in the prober **100**, (4) moving the tray **212** in the horizontal direction toward the opposite side of the prober **100** to detach the wafer **400** from the prober **100**, (5) rotating the tray **212** to face the stocker **300** aide, (6) moving the tray **212** in the vertical direction so that the height becomes a suitable height for storing the wafer **400** in the stocker **300**, (7) moving the tray **212** in the horizontal direction toward the stocker **300** side to store the wafer **400** in the stocker **300**, and (8) moving the tray **212** in the horizontal direction toward the opposite side of the stocker **300** to remove the tray **212** from the stocker **300**. This procedure is only an example and can be changed in various ways, such as reversing the order of (1) and (2), reversing the order of (6) and (7), etc.
(31) Secondly, the storage conveyer **210** then performs an operation for conveying the wafer **400** from the stocker **300** to the prober **100**. Since this procedure is similar to the operation for conveying the wafer **400** from the prober **100** to the stocker **300**, descriptions thereof will be omitted.
(32) The stocker **300** stores a plurality of wafers **400** which are detached from the prober **100**. In the storage device **1** of the present embodiment, a temperature control system (cooling system **310**) is also provided in the stocker **300**. The temperature control system provided in the stocker **300** will be described later.
(33) The air conditioning control system **500** is structured to separate the space in the prober **100** and the like from the outside air, and to replace the inside of the space with dry air, noble gas, inert gas, or the like by flowing them that are absorbed from outside into the space depressurized with an

exhaust fan. The reason why the air conditioning control system **500** replaces the atmosphere in the prober **100**, the storage conveyance system **200**, and the stocker **300** with dry air, noble gas, inert gas, or the like that does not contain water will be explained later.
(34) FIG. **3** is a block diagram schematically showing the storage device **1** that includes the prober **100**, the storage conveyance system **200**, and the stocker **300** described with reference to FIG. **1**.
(35) As described above, in the storage device **1** of the present embodiment, a controller **111-1** that controls writing of data to the NAND chip and reading of data from the NAND chips formed on the wafer **400** is mounted on the printed circuit board PCB of the probe card **110** as one of the devices **111**. A plurality of controllers **111-1** may be mounted. That is, all NAND chips on the wafer **400** can be controlled by a single controller **111-1** or by multiple controllers **111-1**. FIG. **3** shows an example in which, in the same manner as the controller **111-1**, a buffer memory **111-2** for temporarily storing write and read data is mounted on the printed circuit board PCB of the probe card **110** as one of the devices **111**. The buffer memory **111-2** may be integrated into the controller **111-1**.
(36) The controller **111-1** is electrically connected to the NAND chip of the wafer **400** when the probe **115** of the probe card **110** comes in contact with the pad electrode **410** of the wafer **400** on the stage **120**. The controller **111-1** is capable of controlling writing of data to the NAND chip and reading of data from the NAND chip in response to a request from a host **2**. In addition, the wafer **400** in the prober **100** can be replaced with the wafer **400** stored in the stocker **300** by the storage conveyance system **200**.
(37) The storage device **1** includes a control unit **10**. The control unit **10** includes, for example, an air conditioning control unit **11**, a temperature control unit **12**, a drive control unit **13**, and an interface control unit **14**, and controls the entire operation of the storage device **1**. Each control unit of the control unit **10** is realized, for example, by a processor executing firmware. The air conditioning control unit **11** controls the air conditioning control system **500**. The temperature control unit **12** integrally controls the temperature control system in the probe card **110** (the heating and cooling system **112** and the cooling system **113**), the temperature control system in the stage **120** (the heating and cooling system **112**), and the temperature control system in the stocker **300** (the cooling system **310**). The drive control unit **13** controls the drive unit **130** and the storage conveyer **210**. The interface control unit **14** controls the communication between the host **2** and the probe card **11**. The interface control unit **14** controls the air conditioning control unit **11**, the temperature control unit **12**, and the drive control unit **13** based on the control results of the communication.
(38) The writing of data to the NAND chip and the reading of data from the NAND chip of the wafer **400** are preferred to be performed at a high temperature (for example, 75° C., but, for example, 85° C. or lower), above room temperature. More specifically, when data is written to and read from a memory cell in a NAND chip, the higher the temperature, the deeper and more stable the level at which electrons are trapped in the charge storage layer of the memory cell becomes, thereby reducing variations in noise per electron. Therefore, high temperature is preferable. On the other hand, for long-term storage of data in the NAND chip, low temperature (for example, 0° C. or lower), below the room temperature, is preferred. In more detail, charge retention time can be lengthened by suppressing the phonon scattering of the charge stored in the NAND chip. Therefore, low temperature is preferable when storing the wafer **400**. Also, it is preferable to operate the device **111** implemented on the probe card **110** at a temperature equal to or lower than a threshold value. Thus, in the case of using the wafers **400** as storage, various temperature controls are required within the storage device **1**. Therefore, the storage device **1** of the present embodiment has a temperature control system provided for each of the prober **100**, the storage conveyance system **200**, and the stocker **300**, so that appropriate temperature control may be performed for the storage device **1** as a whole. This point is described in detail below.
(39) First, the temperature control system provided in the prober **100** will be described.

(40) As mentioned above, in the prober **100**, temperature control systems are installed in the probe card **110** and in the stage **120**.
(41) In the stage **120** that holds the wafer **400**, the heating and cooling system **121** is provided (see FIG. **1**) to make the temperature in the wafer **400** electrically connected to the probe card **110** on the stage **120** as uniform as possible. The heating and cooling system **121** is a temperature control system using, for example, electric heating and cooling tubes. To control the temperature of the wafer **400** by the stage **120**, the storage device **1** sets a temperature control area for each of areas smaller than the wafer **400**, for example, for each NAND chip area in the wafer **400**, so that different temperature control can be performed for each of them.
(42) FIG. **4** is a diagram for explaining an example of a setting of the temperature control area relating to the stage **120** in the storage device **1** of the present embodiment.
(43) FIG. **4**, part (A) shows a top surface of the wafer **400** and an example of one formation of a NAND chip **420** in the wafer **400**. On the other hand, FIG. **4**, part (B) shows a top surface of the stage **120** holding the wafer **400**, and shows an example of a setting of a temperature control area a**1** for the stage **120**.
(44) As shown in FIG. **4**, in the storage device **1** of the present embodiment, for example, a plurality of temperature control areas a**1** are set on the stage **120** so that they correspond one-to-one in position to a plurality of NAND chips **420** formed on the wafer **400** that is disposed on the stage **120**. For example, the plurality of temperature control areas a**1** can also be set so that one area corresponds to two or more NAND chips **420** in position. The number of NAND chips to which the temperature control area a**1** corresponds does not have to be the same for all the temperature control areas a**1**.
(45) FIG. **5** shows an example of a configuration of the heating and cooling system **121** provided in the stage **12** to control the temperature of each temperature control area a**1** set as shown in, for example, FIG. **4**.
(46) The cooling system of the heating and cooling system **121** has a structure in which refrigerant b**1** is distributed from one of two cooling tubes **1211** to the other via a cooling branch tube **1212**. The refrigerant b**1** is water or liquid nitrogen, etc., cooled by electronic cooling. The cooling branch tube **1212** is disposed so that the wafer **400** on the stage **120** can be cooled per the temperature control area a**1** set on the stage **120**. The cooling by the cooling branch tube **1212** is controlled by the inflow amount of the refrigerant b**1**. To control the inflow amount of the refrigerant b**1**, an electronically controlled motor valve **1213** and a flow meter **1214** are installed, for example, near the inlet of the cooling branch tube **1212**.
(47) On the other hand, the heating system of the heating and cooling system **121** is, for example, configured by using heater wires **1215** that are disposed to heat the wafer **400** on the stage **120** per the temperature control area a**1** set on the stage **120**. The heating by the heater wires **1215** can be controlled by, for example, a switch for switching whether or not to perform heating and a variable resistor for adjusting the calorific value.
(48) Note that, although details will be described later, the heating and cooling system **121** of the stage **120** configured in this manner is controlled by, for example, the controller **111-1** mounted on the probe card **110**. In the stage **120** is provided, for example, a thermometer capable of outputting temperature data to an I.sup.2C bus. A thermometer may also be provided in the wafer **400**.
(49) Between the probe card **110** and the stage **120**, a communication path is provided that is capable of transferring the temperature measured by the thermometer provided in the stage **120** or in the wafer **400** to the controller **111-1**. In cooperation with the control unit **10**, the controller **111-1** controls the heating and cooling system **121** of the stage **120** based on the temperature measured by the thermometer provided in the stage **120** or in the wafer **400**. In a case where there are multiple controllers **111-1**, one of them may be responsible for controlling the heating and cooling system **121**, or multiple controllers **111-1** may work in cooperation to control the heating and cooling system **121**. The control of the temperature control systems (the heating and cooling system **112**

and the cooling system **113**) provided in the probe card **110**, as described below, is also executed by the controller **111-1**. In other words, the temperature control systems in the prober **100** are centrally controlled by the controller **111-1**. A device for centrally controlling the temperature control systems in the prober **100** may be provided separately from the controller **111-1** and mounted on the probe card **110**. Alternatively, a device other than the controller **111-1** may be equipped with a function for centrally controlling the temperature control systems in the prober **110**.
(50) Also, FIG. **5**, a lift pin **131** and an actuator **132** of the drive unit **130** are shown together. The lift pin **131** is a member that is fitted into a hole provided on the stage **120** and moves the stage **120** in a vertical direction or a horizontal direction. The actuator **132** can move the stage **120** in the vertical or the horizontal direction by moving the lift pin **131** in the vertical or the horizontal direction. The movement in the horizontal direction is performed to align the positions of the pad electrode **410** of the wafer **400** and the probe **115** of the probe card **110**. On the other hand, the movement in the vertical direction is performed so that the pad electrode **410** of the wafer **400** and the probe **115** of the probe card **110** come in contact, or so that the pad electrode **410** and the probe **115** that are in a contact state are separated.
(51) FIG. **6** shows an example of an arrangement of the heating and cooling system **121** in the stage **120**, which is configured as shown in, for example, FIG. **5**.
(52) FIG. **6**, part (A) shows a top surface of the wafer **400** and an example of one formation of a NAND chip **420** in the wafer **400**. On the other hand, FIG. **6**, part (B) shows a top surface of the stage **120** holding the wafer **400**, and an example of an arrangement of the heating and cooling system **121** in the stage **120**.
(53) The cooling branch tubes **1212** for cooling and the heater wires **1215** for heating provided in the heating and cooling system **121** described with reference to FIG. **5** do not necessarily have to be disposed to go through all the temperature control areas a**1**, as shown in FIG. **6**, part (B). For example, one or more cooling branch tubes **1212** in the vicinity or one or more heater wires **1215** in the vicinity can be used to control the temperature of the desired temperature control area a**1**.
(54) FIG. **7** is a diagram for explaining an example of temperature control by the heating and cooling system **121** provided in the stage **120**.
(55) FIG. **7**, part (A) shows an example of a case where the temperature in the wafer **400** on the stage **120** is non-uniform. Specifically, it shows a state in which the wafer **400** has high temperature in the center and lower temperature from the center to the edge.
(56) On the other hand, FIG. **7**, part (B) shows an example of temperature control by the heating and cooling system **121** in a case where the wafer **400** is in the state shown in FIG. **7**, part (A).
(57) In this case, to uniformize the temperature, for the center of the wafer **400**, cooling is performed by flowing the refrigerant b**1** into the cooling branch tube **1212** that is disposed in the center, and, for the edge of the wafer **400**, heating is performed by generating heat for the heater wire **1215** disposed at the edge. In this process, the flow rate of the refrigerant b**1** to the cooling branch tube **1212** is controlled to increase as it gets closer to the center and decrease as it gets further away from the center. Instead, the calorific value of the heater wire **1215** is controlled to become smaller as it gets closer to the center and larger as it gets further away from the center.
(58) In this manner, in the storage device **1** of the present embodiment, in which the heating and cooling system **121** is provided in the stage **120**, the temperature in the wafer **400** on the stage **120** can be controlled to be uniform. Note that, in FIG. **7**, for the sake of clarity, a state in which the temperature in the center of the wafer **400** rises, and the temperature in the wafer **400** becomes non-uniform is shown. However, the non-uniformity of the temperature in the wafer **400** may appear in various states depending on an access status to the NAND chip **420**, etc. In the storage device **1** of the present embodiment, which sets a plurality of temperature control areas a**1** on the stage **120**, no matter in what state the non-uniformity of temperature appears, the temperature in the wafer **400** can be appropriately uniformized.
(59) In addition, although details of the cooling system **310** of the stocker **300** will be described

later, the wafer **400** stored in the stocker **300** is cooled to low temperature, below room temperature, which is suitable for long-term storage of data. In contrast, it is preferred that writing of data to the NAND chip **420** and reading of data from the NAND chip **420** be performed at high temperature, above room temperature. In the storage device **1** of the present embodiment in which the heating and cooling system **121** is provided in the stage **120**, when replacing the wafer **400** in the prober **100**, it is possible to raise the temperature of the wafer **400** conveyed from the stocker **300** at low temperature to temperature suitable for writing data to the NAND chip **420** and reading data from the NAND chip **420** before being electrically connected to the probe card **110**. Furthermore, upon contact, it is also possible to prevent both the probe **115** of the probe card **110** and the pad electrode **410** of the wafer **400** from being damaged.

(60) In addition, in the storage device **1** of the present embodiment where the stage **120** is provided with the heating and cooling system **121**, when replacing the wafer **400** in the prober **100**, the wafer **400** on the stage **120** maintained above room temperature can be cooled, for example, below room temperature on the stage **120** after it is electrically disconnected from the probe card **110**, and before it is conveyed to the stocker **300**. By storing the wafer **400** that has been cooled on the stage **120**, in the stocker **300**, it is possible to prevent the temperature in the stocker **300** from rising, even if temporarily, and prevent the effect on other wafers **400** in the stocker **300**. Furthermore, a cooling system may also be provided in the storage conveyance system **200** interposed between the prober **100** and the stocker **300** to cool the wafer **400** that has been maintained above room temperature on the stage **120** of the prober **100** to below room temperature.

(61) As the temperature control system in the probe card **110**, the heating and cooling system **112**, the cooling system **113**, and the heat insulating material **114** (see FIG. **1**) are provided.

(62) The heating and cooling system **112** is, for example, a temperature control system using electric heating and cooling tubes similar to the heating and cooling system **121** of the stage **120**. Since it may be similar to the heating and cooling system **121** of the stage **120**, descriptions of the configuration thereof will be omitted. It may also be configured differently from the heating and cooling system **121** of the stage **120**.

(63) The heating and cooling system **112** is provided on, for example, the bottom surface side in the probe card **110**, facing the wafer **400** on the stage **120**, so that the temperature of the probe card **110** roughly matches the temperature of the wafer **400**, or more precisely, so that the temperature of the probe **115** roughly matches the temperature of the pad electrode **410**.

(64) This enables the storage device **1** of the present embodiment to stabilize the electrical connection between the wafer **400** and the probe card **110** when the probe **115** contacts the pad electrode **410**.

(65) The cooling system **113** of the probe card **110** is, for example, a temperature control system using heat dissipation or cooling tubes. The cooling system **113** is provided on, for example, the top surface side in the probe card **110** to operate the device **111** mounted on the printed circuit board PCB of the probe card **110** at a temperature equal to or lower than a threshold value; in other words, so that the temperature of the device **111** does not exceed the threshold value. The control of the cooling system **113** is executed by the controller **111-1**, which is one of the devices **111**. The controller **111-1** controls the cooling system **113** based on the temperature of the controller **111-1** measured by itself or the temperature measured by other devices on the printed circuit board PCB. The cooling system **113**, like the heating and cooling system **112** and the heating and cooling system **121** of the stage **120**, can control the temperature in each temperature control area set in advance. This temperature control area may correspond to the temperature control area a**1** set on the stage **120**, or may be set independently.

(66) This allows the storage device **1** of the present embodiment to continue operating the device **111** mounted on the probe card **110** in appropriate environment.

(67) In addition, the probe card **110** is provided with a heat insulating material with high thermal resistance between, for example, the top surface where the device **111** is mounted and, for example,

the bottom surface facing the wafer **400**. By installing the heat insulating material **114**, the storage device **1** of the present embodiment thermally insulates the inside of the probe card **110** between the top surface side and bottom surface side, enabling different temperatures to be maintained, respectively. More specifically, for example, the top surface side can be maintained at temperature suitable for the device **111**, and, for example, the bottom surface side can be maintained at temperature that roughly matches the temperature of the wafer **400** on the stage **120**.
(68) FIG. **8** is a diagram for explaining an example of a mechanism in which the device **111** (the controller **111-1**) on the probe card **110** centrally controls the temperature of the prober **100** in the storage device **1**.
(69) The probe card **110** is provided with a ceramic printed circuit board PCB **1101** having high heat dissipation effect. Some of the devices **111** disposed on, for example, the top surface of this ceramic printed circuit board PCB **1101** includes a thermometer **1111** that measures the temperature of the device **111**. The controller **111-1** also includes the thermometer **1111**. The controller **111-1** first executes temperature control using the cooling system **113** so that the temperature of the device **111** is maintained at or below a threshold value based on the temperature measured by these thermometers **1111**, including its own thermometer **1111**. As described above, the controller **111-1** can execute temperature control using the cooling system **113** in each temperature control area that is set in advance. The thermometer **1111** that measures the temperature of the device **111** may be outside the device **111**.
(70) For example, on the bottom surface of the ceramic printed circuit board PCB **1101**, a probe unit **1103** is disposed via an interposer **1102**. The probe **115** is provided at a distal end portion of the probe unit **1103**. Furthermore, on the bottom surface side of the ceramic printed circuit board PCB **1101**, for example, a thermometer **1104** that can output temperature data to the controller **111-1** is provided.
(71) In addition, as mentioned above, a thermometer (**430**, **1201**) is provided in at least one of the wafer **400** and the stage **120**. The controller **111-1** secondly executes temperature control using the heating and cooling system **112** of the probe card **11** and the heating and cooling system **121** of the stage **120** so that the temperature of the probe **115** and the temperature of the pad electrode **410** roughly match based on the temperature measured by the thermometer **1104** provided in the probe card **110** and the temperature measured by the thermometer **430** provided in the wafer **400** or the temperature measured by the thermometer **1201** provided in the stage **120**. At the same time, the controller **111-1** executes temperature control using the heating and cooling system **121** of the stage **120** so that the temperature in the wafer **400** becomes uniform.
(72) In other words, in the storage device **1** of the present embodiment, the device **111** disposed on the probe card **110** is capable of monitoring the temperature of multiple locations of the probe card **110**, the stage **120**, and the wafer **400** on the stage **120**.
(73) Note that, in FIG. **8**, a formation on the wafer **400** indicated by symbol c**1** is an alignment mark used for aligning the probe **115** of the probe card **110** with respect to the pad electrode **410**. Furthermore, in FIG. **8**, the X direction is a direction of word lines and the Y direction is a direction of the bit lines. The movement of the stage **120** holding the wafer **400** in the horizontal direction by the drive unit **130** is performed with reference to this alignment mark c**1**. The probe card **110** may be provided with a camera for detecting a representative position (here, the alignment mark c**1**) on the wafer **400**. The drive control unit **13** can recognize a reference position more accurately based on the information from the camera, and can perform precise alignment.
(74) FIG. **9** shows a plurality of probes **115** disposed on a first surface **110**A of the probe card **110**.
(75) In FIG. **9**, a case is exemplified in which the same number of probes **115** as the number of pad electrodes **410** of all NAND chips **420** of the wafer **400** are disposed on the first surface **110**A of the probe card **110**.
(76) In this case, the probes **115** of the probe card **110** are in contact with all pad electrodes **410** of all NAND chips **410** in the wafer **400** all at once, and all the NAND chips can be controlled by the

controller **111-1**.
(77) FIG. **10** shows a plurality of controllers **111-1** disposed on a second surface **110**B of the probe card **110**.
(78) In FIG. **10**, a case in which 16 controllers **111-1** (controllers **111-1-1**, **111-1-2**, . . . , **111-1-16**) are disposed is exemplified. In a case where a single wafer includes 1024 NAND chips **420**, and 16 controllers **111-1** are disposed on the second surface **110**B of the probe card **110**, each controller **111-1** should control 64 NAND chips **420** via the probe **115**.
(79) FIG. **11** is a diagram for explaining an example of an operation of the device **111** implemented on a prober **100**.
(80) Here, it is assumed that a plurality of controllers **111-1** share control of a plurality of NAND chips **420** formed on the wafer **400**. In other words, it is assumed that multiple controllers **111-1** are disposed on the probe card **110**.
(81) A connector **111-3** into which a riser cable **111**A for connecting the probe card **110** to an external device, such as the host **2** (see FIG. **3**), is inserted is disposed on the probe card **110**. An interface switch (for example, a PCIe (registered trademark) switch) **111-4** for exclusively and selectively connecting to the connector **111-3** and one controller **111-1** among multiple controllers **111-1** is disposed on the probe card **110**. By the interface switch **111-4** switching appropriately, for example, when data read is requested from the host **2**, the data read request is transmitted to the controller **111-1** that controls the corresponding NAND chip **420**. The controller **111-1** that receives this request reads the data from the NAND chip **420**, and transmits the read data to the host **2**. The data transmitted from the controller **111-1** is relayed to the connector **111-3** by the interface switch **111-4**, and is transferred to the host **2** via the riser cable **111**A.
(82) In the storage device **1** of the present embodiment, the temperature of these multiple devices **111** that are disposed on the probe card **110** is maintained at or below a threshold value by the cooling system **113** of the probe card **110**. Furthermore, in addition to the controller **111-1** and the interface switch **111-4**, various LSI chips and semiconductor components such as FPGAs, relays, capacitors, etc., may be implemented on the prober **100**.
(83) Next, the cooling system **310** provided in the stocker **300** will be described.
(84) FIG. **12** shows a first example of the cooling system **310**.
(85) The stocker **300** is provided with the same number of shutters **301** that open and close when the wafers **400** are taken in and out, as the number of wafers **400** that can be stored therein. When taking out the wafers **400** from the stocker **300** or storing the wafers **400** in the stocker **300**, to prevent cool air in the stocker **300** from escaping, any shutter **301** among the plurality of shutters **301** is selectively opened and closed. Note that the stocker **300** may also be configured to have one shutter **301** and move the entire stock of the storages (wafers **400**) stored therein up and down.
(86) In the first example, the stocker **300** is provided with an intake port **311** for feeding cooling air d**1**, and an exhaust port **312** for discharging cooling air d**2** that has flowed through the stocker **300**. The cooling air d**1** is, for example, cooled air under high pressure. The cooling system **310** of the stocker **300** in the present example closes the entrance and exit of the wafer **400** with the shutter **301**, continues to feed the cooling air d**1** from the intake port **311**, and continues to fill the stocker **300** with the cooling air d**1** that is kept below room temperature, to thereby cool the entire stocker **300**. In other words, the wafer **400** in the stocker **300** is cooled so that the temperature becomes suitable for long-term storage of data.
(87) FIG. **13** shows a second example of the cooling system **310**.
(88) In the second example, a cooling tube **313** for distributing refrigerant e**1** is provided, for example, on the side peripheral wall of the stocker **300** so as to cover the entire side surface of the stocker **300**. The refrigerant e**1** is water or liquid nitrogen cooled by electronic cooling. The cooling system **310** of the stocker **300** in the present example closes the entrance and exit of the wafers **400** by the shutters **301**, distributes the refrigerant e**1** to the cooling tube **313** provided on the peripheral wall of the stocker **300**, and cools the air inside the stocker **300**, to thereby cool the entire stocker

300. In other words, the wafer **400** in the stocker **300** is cooled to temperature suitable for long-term storage of data. Note that the cooling tube **313** may be provided inside the stocker **300**.
(89) In addition to using the cooling air d**1** and the refrigerant e**1**, for example, an electronic cooling system using Peltier elements may be provided on a portion supporting the wafer **400** in the stocker **300**, a portion connected to this support portion, or the entire stocker **300**, to thereby cool the wafer **400** in the stocker **300**.
(90) In this manner, in the storage device **1** of the present embodiment in which the stocker **300** is provided with the cooling system **310**, it is possible to store the wafers **400** in the stocker **300** while maintaining low temperature below room temperature, which is suitable for long-term storage of data.
(91) Next, the air conditioning control system **500** (see FIG. **1**) will be described.
(92) As described above, the wafers **400** in the stocker **300** are cooled to low temperature below room temperature. Therefore, in the case of taking out a wafer **400** from the stocker **300** and conveying the wafer **400** to the prober **100** to replace a wafer **400** in the prober **100** with the wafer **400** in the stocker **300**, there is a possibility that the water vapor in the air in the storage conveyance system **200** may condense (i.e., condensation may occur) on the low-temperature wafer **400** and on the storage conveyer **210** that conveys the wafer **400**. To prevent this condensation, the storage device **1** of the present embodiment is provided with the air conditioning control system **500** to replace the atmosphere in the storage conveyance system **200** with dry air, noble gas, inert gas, or the like that does not contain water.
(93) The air conditioning control system **500** not only replaces the atmosphere in the storage conveyance system **200** but also in the prober **100** and the stocker **300** with dry air, noble gas, inert gas, or the like that does not contain water. As a result, in the storage device **1** of the present embodiment, condensation can be prevented almost completely on the wafer **400**. Note that, since it is preferable that there is no oxygen in addition to water in the space where the wafer **400** is handled, it is preferable to replace the atmosphere in the prober **100**, the storage conveyance system **200**, and the stocker **300** with noble gas or inert gas.
(94) Furthermore, since it is preferable to cool not only the inside of the stocker **300** but also the inside of the storage conveyance system **200** that conveys, to the stocker **300**, the wafers **400** that have been maintained at high temperature above room temperature in the prober **100**, the cooling system may also be provided in the storage conveyance system **200** as described above.
(95) Furthermore, the stocker **300** is cooled to maintain the charge retention properties of the NAND chips **420** of the wafers **400** for a long time. The temperature of the wafer **400** may be at room temperature; however, since the cooler the temperature, the higher the charge retention property is, a temperature of 0° C. or lower may also be used. However, at the low temperature equal to or lower than 0° C., there may be electrical side effects due to condensation of water in the atmosphere, such as a short circuit between wires. From this point of view, it is preferable to replace the atmosphere in the stocker **300** with dry air, noble gas such as argon, or inert gas such as nitrogen that does not contain water.
(96) In this manner, in the storage device **1** of the present embodiment that is provided with the air conditioning control system **500**, which is a kind of temperature control system, condensation can be prevented on the wafer **400** and on the storage conveyer **210**.
(97) FIG. **14** is a flowchart showing an example of a flow of the temperature control at the time of replacement of the wafer **400** executed in the storage device **1** of the present embodiment.
(98) The storage device **1** electrically disconnects the wafer **400** from the probe card **110** using the drive unit **130** (S**1**). The storage device **1** cools the wafer **400** electrically disconnected from the probe card **110** on the stage **120** (S**2**). In this process, the controller **111-1** acquires the temperature from the thermometer (**430**, **1201**) through, for example, the I.sup.2C bus. The storage device **1** conveys the wafer **400** cooled, for example, below room temperature from the prober **100** to the stocker **300** by the storage conveyance system **200** (S**3**).

(99) Subsequently, the storage device **1** conveys the wafer **400** to be accommodated in the prober **100** in replacement with the wafer **400** taken out from the prober **100**, from the stocker **300** to the prober **100** using the storage conveyance system **200** (S**4**). The storage device **1** raises the temperature of the wafer **400** to be electrically connected to the probe card **110** on the stage (S**5**). Again, in this process, the controller **111-1** acquires the temperature from the thermometer (**430**, **1201**) through, for example, the I.sup.2C bus. The storage device **1** electrically connects the wafer **400**, which has been raised to, for example, temperature above room temperature that is suitable for writing and reading data to the NAND chip **420**, with the probe card **110** using the drive circuit (S**6**).
(100) As described above, the storage device **1** of the present embodiment, in which the temperature control system is provided in each of the prober **100**, the storage conveyance system **200**, and the stocker **300**, can appropriately perform various temperature controls for the wafer **400**.
(101) In addition, the heating and cooling system **121** provided in the stage **120** of the prober **100** can be used to refresh the wafer **400**. The refresh is a process for leveling variations in properties between memory cells in a NAND chip for writing or reading of data, which have been degraded by read/write stress. This process also recovers the data retention function of the NAND chip. For example, to recover degradation by annealing at approximately 300° C., the temperature of the wafer **400** is raised on the stage **120** and the refresh is performed. For this purpose, an intake port provided in the prober **100** and a supply system provided in the prober **100** for nitrogen, argon, helium, krypton, xenon, and the like are used to seal the inside of the prober **100** with these inert gases. In other words, the concentration of water and oxygen included in the atmosphere is reduced. Note that a different atmosphere may be used to seal each area in the prober **100**. In this manner, by replacing the atmosphere with inert gas, and using the heating and cooling system **121** provided in the stage **120**, the electrodes of the wafer **400** can be prevented from oxidation. In other words, in the storage device **1** of the present embodiment, a refresh system that raises the temperature of the wafer **400** on the stage **120** and seals the area around the wafer **400** with an inert gas may be provided in the prober **100**.
(102) 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.

Claims

1. A storage device comprising: a control apparatus configured to write data to or read data from a storage medium that includes a plurality of non-volatile memory chips; and a stocker configured to store a plurality of the storage media that are detached from the control apparatus, wherein the control apparatus includes a first temperature control system configured to raise temperature of the storage medium to a first temperature or higher, and the stocker includes a second temperature control system configured to cool the storage medium to a second temperature or lower, the second temperature being lower than the first temperature.
2. The storage device of claim 1, wherein the control apparatus further includes: a stage configured to hold the storage medium; a probe card including a plurality of probes on a first surface, the first surface facing the storage medium when the storage medium is held by the stage; and a drive unit configured to: move at least one of the stage or the probe card to bring a plurality of pad electrodes provided on the storage medium into contact with the plurality of probes, the plurality of pad electrodes being provided on a surface of the storage medium that faces the probe card when the

storage medium is held by the stage; or separate the plurality of pad electrodes and the plurality of probes that are in contact with each other, wherein the drive unit is configured to bring the plurality of pad electrodes of the storage medium into contact with the plurality of probes after the first temperature control system raises the temperature of the storage medium to the first temperature or higher on the stage.
3. The storage device of claim 2, wherein the first temperature control system includes a plurality of temperature control systems formed in the stage, each of the plurality of temperature control systems being configured to perform temperature control for each of a plurality of areas of the storage medium held by the stage.
4. The storage device of claim 3, wherein the first temperature control system is configured to maintain temperature of each of the plurality of areas of the storage medium within a first range using the plurality of temperature control systems.
5. The storage device of claim 4, wherein the plurality of areas are areas corresponding to respective positions of the plurality of non-volatile memory chips in the storage medium.
6. The storage device of claim 2, wherein the first temperature control system includes a temperature control system configured to control temperature of the first surface of the probe card.
7. The storage device of claim 2, wherein the probe card further includes a plurality of semiconductor components on a second surface opposing to the first surface, and the first temperature control system includes a temperature control system configured to cool the plurality of semiconductor components on the second surface.
8. The storage device of claim 7 wherein the probe card further includes heat insulating material between the first surface and the second surface.
9. The storage device of claim 7, wherein the plurality of semiconductor components include at least one of (A) at least one controller configured to control the non-volatile memory chips, (B) an interface switch configured to selectively operate a plurality of the controllers, (C) a relay, and (D) a capacitor.
10. The storage device of claim 7, wherein at least one of the plurality of semiconductor components is configured to monitor at least one of temperature measured by a thermometer provided in the stage and temperature measured by a thermometer provided in the probe card.
11. The storage device of claim 1, wherein the second temperature control system includes a cooling system configured to use cooling water, cooling air or liquid nitrogen as refrigerant.
12. The storage device of claim 1, wherein the second temperature control system includes an electronic cooling system configured to use a Peltier element provided in a first portion configured to hold the storage medium, or in a second portion connected to the first portion.
13. The storage device of claim 2, wherein the control apparatus further includes a refresh system configured to seal around the storage medium with a noble gas or an inert gas, and to raise the temperature of the storage medium on the stage using the first temperature control system.
14. The storage device of claim 13, wherein the noble gas or the inert gas is one of nitrogen, argon, helium, krypton, or xenon.
15. The storage device of claim 2, wherein the control apparatus is further configured to, when replacing the storage medium in contact with the plurality of probes from a first storage medium to a second storage medium stored in the stocker, cool the first storage medium maintained to the first temperature or higher, to lower than the first temperature on the stage using the first temperature control system.
16. The storage device of claim 2, wherein the control apparatus is further configured to, when replacing the storage medium in contact with the plurality of probes from a third storage medium to a fourth storage medium stored in the stocker, raise temperature of the fourth storage medium cooled to the second temperature or lower, to the first temperature or higher on the stage using the first temperature control system, and bring the plurality of pad electrodes of the fourth storage medium into contact with the plurality of probes using the drive unit.

17. The storage device of claim 1, further comprising a conveyance system configured to convey the storage medium from the control apparatus to the stocker or convey the storage medium from the stocker to the control apparatus, wherein the first temperature is room temperature, and the conveyance system includes a third temperature control system configured to adjust air in the conveyance system for a purpose of preventing condensation during conveyance of the storage medium cooled to the second temperature or lower from the stocker to the control apparatus.
18. The storage device of claim 1, wherein the storage medium is a semiconductor wafer.
19. A control method of a storage device, the storage device including a control apparatus and a stocker, said method comprising: raising temperature of a storage medium that includes a plurality of non-volatile memory chips to a first temperature or higher, in the control apparatus that is configured to write data to or read data from the storage medium loaded on a stage; cooling a plurality of the storage media to a second temperature or lower, while the stocker stores the plurality of the storage media detached from the control apparatus, the second temperature being lower than the first temperature; and when replacing the storage medium connected to a probe card of the control apparatus from a first storage medium to a second storage medium stored in the stocker, cooling the first storage medium maintained to the first temperature or higher, to lower than the first temperature in the control apparatus; raising temperature of the second storage medium cooled to the second temperature or lower, to the first temperature or higher in the control apparatus; and loading the second storage medium on the stage.
20. The control method of claim 19, wherein the storage medium is a semiconductor wafer.