WAFER CHUCK, TEMPERATURE CONTROL SYSTEM, AND TEMPERATURE CONTROL METHOD

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a wafer chuck, a temperature control system, and a temperature control method.

Description of the Related Art

[0002] In a semiconductor manufacturing process, various treatments are applied to a semiconductor wafer to form chips (dice) each including a semiconductor device. The electrical properties of each chip are tested, and then chips are individually divided (diced) by a dicer. Subsequently, each chip is fixed to a lead frame or the like, and is assembled. The electrical properties are tested by a wafer test system that includes a prober and a tester. The prober fixes the wafer on the wafer chuck, and brings a probe into contact with an electrode pad of each chip. The tester provides power supply and various test signals through terminals connected to the probe, analyzes a signal output from the electrode of the chip, and verifies whether a semiconductor device on the chip, which is a test target, normally operates or not.

[0003] The prober is required to bring the temperature during testing of the electrical properties to a set temperature, and maintain the temperature constant. Accordingly, to cope with heat generation of the semiconductor device (device to be measured, measurement target device) of a chip to be tested, temperature sensors, such as resistance temperature detectors or thermocouple-type temperature sensors, are installed in a wafer chuck to detect the temperature and the amount of heat generation, and temperature of the wafer chuck is controlled based on the detection results of the temperature sensors.

[0004] For example, according to a prober disclosed in Patent Literature 1, temperature sensors are arranged in a wafer chuck (prober chuck), and temperature of the wafer chuck is controlled based on a detection result of a temperature sensor closest to the measurement target device to be tested among the temperature sensors.

Citation List

Patent Literature(s)

[0005] Patent Literature 1: Japanese Patent Application Laid-Open No. 2006-294873

SUMMARY OF THE INVENTION

[0006] In the prober disclosed in Patent Literature 1, to correctly measure the temperature of the wafer chuck that corresponds to a heat generating part of the device to be measured, it is required to increase the number of temperature sensors installed in the wafer chuck. However, due to a structural limitation in the wafer chuck, the number of installations and the installation positions are limited, and it is difficult to embed a large number of temperature sensors at ideal positions. In the case where a large number of temperature sensors are installed, the number of required sets of signal lines of the temperature sensors increases as increase in the number of temperature sensors, and it is significantly difficult to lay out their wiring.

[0007] In particular, in a case where the device to be measured is a an SoC (System On Chip) type device, such as a CPU (Central Processing Unit), a GPU (Graphics Processing Unit), or an APU (Accelerated Processing Unit), its heat generation has a locally high heat density in comparison with a memory device. Accordingly, in a case where many temperature sensors cannot be installed in the wafer chuck, it is difficult to appropriately control the temperature of the wafer chuck to cope with heat generation of the device to be measured.

[0008] Embodiments of the present invention provide a wafer chuck that can measure temperature of the wafer chuck corresponding to a heat generating part of a wafer without increasing the number of installed temperature sensors, and a temperature control system and a temperature control method that can appropriately control the temperature of the wafer chuck.

[0009] According to a first aspect of the present invention, there is provided a wafer chuck having a holding surface for holding a wafer, the wafer chuck including: a heating and cooling unit configured to heat or cool the wafer chuck; at least one temperature sensor disposed in the wafer chuck; and a heat flow sensor which is disposed in the wafer chuck, and in which a plurality of thermocouples are connected in series and connecting parts between ones adjacent to each other of the thermocouples are alternately disposed at a first depth position from the holding surface and at a second depth position deeper than the first depth position, wherein the temperature sensor is used to measure a reference temperature that is a temperature at the second depth position in a corresponding part being a part corresponding to a heat generating part of the wafer on the wafer chuck, the heat flow sensor

has a plurality of temperature measurement points provided for the respective thermocouples, the plurality of temperature measurement points being disposed over an entirety of the wafer chuck when the wafer chuck is seen in plan view, and the heat flow sensor is used to measure a vertical temperature difference between the first depth position and the second depth position in the corresponding part.

[0010] According to this wafer chuck, the temperature of the wafer chuck corresponding to the heat generating part of the wafer may be measured without increasing the number of installed temperature sensors.

[0011] In the wafer chuck according to an embodiment of the present invention, a plurality of the temperature sensors are disposed in a distributed manner. Accordingly, when the device to be measured on the wafer to be tested generates heat, the temperature of the wafer chuck at a part that is not affected by the heat generation may be detected by at least one of the temperature sensors.

[0012] According to a second aspect of the present invention, there is provided a temperature control system that includes: the above-described wafer chuck; and a temperature control unit configured to calculate a temperature of the corresponding part or the heat generating part as a control temperature, based on a detection result of the temperature sensor and on a detection result of the heat flow sensor.

[0013] According to the temperature control system, the temperature of the wafer chuck may be appropriately controlled without increasing the number of temperature sensors arranged in the wafer chuck.

[0014] In the temperature control system according to an embodiment of the present invention, the temperature control unit executes: a process of detecting, based on the detection result of the temperature sensor, the reference temperature; a process of calculating the vertical temperature difference, based on the detection result of the heat flow sensor; and a process of calculating, as the control temperature, a temperature of a heat generating part temperature measurement point that is a temperature of the corresponding part, based on the reference temperature and the vertical temperature difference. Accordingly, the temperature of the wafer chuck may be appropriately controlled without increasing the number of temperature sensors arranged in the wafer chuck.

[0015] In the temperature control system according to another embodiment of the present invention, the temperature control unit executes: a process of detecting, based on the detection result of the temperature sensor, the reference temperature; a process of calculating

the vertical temperature difference, based on the detection result of the heat flow sensor; and a process of calculating, as the control temperature, a device temperature that is a temperature of the heat generating part, based on the reference temperature, on the vertical temperature difference, and on data that includes physical property values and dimensions of the wafer and the wafer chuck. Accordingly, the temperature of the wafer chuck may be appropriately controlled without increasing the number of temperature sensors arranged in the wafer chuck.

[0016] In the temperature control system according to another embodiment of the present invention, in the wafer chuck, a plurality of the temperature sensors are disposed in a distributed manner, and the temperature control unit detects, as the reference temperature, a lowest temperature among temperatures respectively detected by the plurality of temperature sensors, or an average or a median of the temperatures detected by the plurality of temperature sensors.

[0018] According to a third aspect of the present invention, there is provided a temperature control method of controlling a temperature of the above wafer chuck, the method including: a reference temperature detecting step of detecting, by the at least one temperature sensor, the reference temperature of the wafer chuck; a heat flow detecting step of detecting, by the heat flow sensor, a heat flow caused by partial heat generation of the wafer held on the holding surface; and a temperature control step of calculating the vertical temperature difference, based on a detection result of the heat flow detecting step, and calculating a temperature of the corresponding part or the heat generating part as a control temperature, based on the reference temperature detected in the reference temperature detecting step and the vertical temperature difference.

[0019] In the temperature control method according to an embodiment of the present invention, the temperature control step includes a process of calculating, as the control temperature, a temperature of a heat generating part temperature measurement point that is a temperature of the corresponding part, based on the reference temperature and the vertical temperature difference.

[0020] In the temperature control method according to another embodiment of the present invention, the temperature control step includes a process of calculating, as the control temperature, a device temperature that is a temperature of the heat generating part, based on the reference temperature, on the vertical temperature difference, and on data that includes physical property values and dimensions of the wafer and the wafer chuck.

[0022] According to embodiments of the present invention, the temperature of the wafer chuck corresponding to the heat generating part of the wafer can be measured without increasing the number of installed temperature sensors. The temperature of the wafer chuck can be appropriately controlled.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] Figure 1 is a schematic diagram showing an entire configuration of a wafer test system.

Figure 2 is a schematic configuration diagram of a temperature control system in a first embodiment.

Figure 3 shows a schematic plan view and an enlarged sectional view illustrating an internal structure of the wafer chuck.

Figure 4 is a functional block diagram showing the configuration of a temperature control device in the first embodiment.

Figure 5 is a conceptual diagram of a calculation example of the area of a heat generating part obtained from a heat flow sensor.

Figure 6 is a flowchart showing an example of a temperature control method in the temperature control system in the first embodiment.

Figure 7 shows a configuration example in a case where the heat flow sensor includes two sensor elements.

Figure 8 is a schematic configuration diagram of a temperature control system according to a first modified example.

Figure 9 is a schematic configuration diagram of a temperature control system according to a second modified example.

Figure 10 is a functional block diagram showing the configuration of a temperature control device in a second embodiment.

Figure 11 is an illustration diagram for illustrating a method of calculating a device temperature.

DESCRIPTION OF THE EMBODIMENTS

[0024] Hereinafter, a preferable embodiment of the present invention is described with reference to the accompanying drawings.