CALORIMETER AND MANUFACTURING METHOD THEREOF

BACKGROUND OF THE INVENTION

The present invention relates to a superconducting radiation detector, and to a method of manufacturing a calorimeter having a membrane for controlling thermal conductivity and arranged a specified distance from a substrate.

Currently, development of calorimeters using a superconducting transition edge is being carried out in various research laboratories. As a reference publication, there is, for example, Applied Physics Letters 66,1988(1995). In this publication, a calorimeter comprises an absorber for absorbing radiation and converting energy of the radiation into thermal energy, a resistor attached to the absorber for converting the thermal energy into an electrical signal, and a membrane for externally discharging heat. The calorimeter maintains a steady state by balancing joule heat generated by electrical current flowing in the resistor and heat discharged to the outside through the membrane. The membrane applies micromachining technology, and uses a thin insulator under 1 μm. A silicon nitride film is used as the insulator.

A conventional membrane production method uses a silicon substrate on which at least a silicon nitride film is deposited on the one side of silicon substrate, and after manufacturing an absorber and a resistor on the surface of the formed silicon nitride film, the silicon is etched from the back surface (reference publication IEEE Trans. Appl. Super. 5,2690(1995)). With the conventional manufacturing method, it is necessary to perform double surface patterning, because the silicon is etched from the back surface. As a result, since both surfaces of a wafer are grounded to an exposure device holder, there is a danger of elements being contaminated. Further, if the silicon is etched from a back surface, in order to completely etch the thick parts of the wafer it has been considered to degrade mechanical strength. In particular, when a calorimeter is arrayed, there is a need to etch from the back surface only for the array number, and it has been considered to further improve the mechanical strength of the whole substrate. A manufacturing method for a membrane using a conventional sacrificial layer is also shown. A sacrificial layer is formed on the substrate, an insulating film is formed on the sacrificial layer and the sacrificial layer is etched to form a membrane. However, if this method is used, a stepped region is inevitably formed on part of the membrane, and it is difficult to maintain mechanical strength of a substrate rather than a substrate before etching as it is easy for cracks and the like to occur.

SUMMARY OF THE INVENTION

In order to solve these type of problems, there is provided a calorimeter having an absorber for converting energy of radioactive rays into thermal energy, and a resistor for converting thermal energy into an electrical signal using superconducting transition and arranged on a membrane for controlling thermal discharge from the resistor. The membrane is attached to a substrate having a tri-layer structure of an etching layer, an etching stop layer and a support substrate, with the membrane being arranged separated by the thickness of the etching layer apart from the etching stop layer.

As a result, the support substrate exists at a lower portion maintaining a specified distance from the membrane. If the thickness of the etching layer is, for example, 30 μm, and the support substrate is, for example, 500 μm, the mechanical strength of the substrate after etching the etching layer is sufficiently strong because the support substrate is sufficiently thick compared to the etching layer. If the membrane is bridged, it is possible to obtain a membrane having a degree of thermal conductivity according to design parameters by varying the length and thickness. By using a substrate having a tri-layer structure of an etching layer, an etching stop layer and a support substrate, and forming elements on a membrane formed as a film on the etching layer side, elements and membrane patterning are on the same surface, and there is no danger of contaminating the pattern surface.

There is also provided a manufacturing method for a calorimeter having an absorber for converting energy of radioactive rays into thermal energy, and a resistor for converting thermal energy into an electrical signal using a superconducting transition and arranged on a membrane for controlling thermal discharge from the resistor. The membrane is attached to a substrate having a tri-layer structure of an etching layer, an etching stop layer and a support substrate. According to the present invention, the is arranged in a specified direction and the etching layer is etched from the etching layer side.

As a result, it is possible to more easily perform wet etching of the etching layer underneath the membrane, and it is possible to have the membrane separated by the thickness of the etching layer apart from the support substrate. In particular, by forming the etching layer from planar (100) oriented silicon, and arranging the orientation of the membrane to <100>, it is made possible to etch the etching layer in a short time.

There is also provided a manufacturing method for a calorimeter having an absorber for converting energy of radioactive rays into thermal energy, and a resistor for converting thermal energy into an electrical signal using a superconducting transition and arranged on a membrane for controlling thermal discharge from the resistor. The membrane is attached to a substrate having a tri-layer structure of an etching layer, an etching stop layer and a support substrate. According to the present invention, a hollow is provided at part of the etching layer, a sacrificial layer is provided, a surface of the etching layer is flattened, and the etching layer is etched from the etching layer side.

Since the back surface of the etching layer is flattened, no stepped portion is caused in the membrane formed after etching of an amorphous material constituting the sacrificial layer. Therefore, there is no effect of cracks or the like occurring in a stepped portion of the membrane, which means that the mechanical strength of the membrane is improved. Also, since the amorphous layer does not have crystallinity, the etching rate is also fast. As a result, it is possible to reduce the time taken to manufacture a calorimeter. Also, since the amorphous layer does not have crystallinity, it is possible to freely choose the shape of the membrane, and it is easy to adjust the thermal conductivity.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic drawing showing a calorimeter relating to embodiment 1 of the present invention;

FIG. **2** is a schematic drawing showing a calorimeter relating to embodiment 2 of the present invention, and a manufacturing method thereof;

FIG. **3** is a schematic drawing showing a calorimeter relating to embodiment 2 of the present invention, and a manufacturing method thereof;

FIG. **4** is a schematic drawing showing a calorimeter relating to embodiment 2 of the present invention, and a manufacturing method thereof;