

**MAGNETIC FIELD MEASURING
OPTICALLY PUMPED MAGNETOMETER
APPARATUS**

CLAIM OF PRIORITY

The present application claims priority from Japanese application JP 2007-168373 filed on Jun. 27, 2007, the content of which is hereby incorporated by reference into this application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a technique for retaining the heat of a sensor part of an optically pumped magnetometer.

2. Background Art

In order to increase alkali metal atoms in a vapor cell which are excited by irradiation light applied to the cell, it is necessary to increase the gas density of the alkali metal in the cell by heating the cell. In order to retain the heat of the cell, there are techniques using hot air or heaters.

Appl. Phys. B76, 325-328 (2003) discloses that a cell is housed in a plastic coiled tube and the heat of the cell is retained by applying hot air to the inside of the tube using a hot air generator.

APPLIED PHYSICS LETTERS 85, 6409 (2004) discloses that transparent film heaters are provided to the parts through which irradiation light applied to a cell passes, and the heat of the cell is retained by applying current to the transparent film heater.

APPLIED PHYSICS LETTERS 89, 134105 (2006) discloses that hot air is applied to the inside of an oven housing a cell using a hot air generator to fill that container with hot air, thereby retaining the heat of the cell.

REVIEW OF SCIENCE INSTRUMENTS 77, 113106 (2006) discloses that hot air is applied using a hot air generator to the inside of a magnetic shielding provided to suppress environmental magnetic noise coming into a cell to fill the magnetic shielding with hot air, thereby retaining the heat of the cell.

JP Patent Publication (Kokai) No. 2001-339302A discloses that a c-field control circuit and a heater coil control-equipped temperature control circuit are prepared and a c-field coil wound on a cavity housing a cell is used as a heater by means of a coil function switch device, thereby retaining the heat of the cell.

JP Patent Publication (Kokai) No. 2002-344314A discloses that a film heater is provided to a c-field coil wound on a cavity housing a cell, or a cell, and current is applied to the film heater, thereby retaining the heat of the cell.

JP Patent Publication (Kokai) No. 2003-229766A discloses that a cell is housed in a metal case provided with a heater, and current is applied to the heater, thereby retaining the heat of the cell.

SUMMARY OF THE INVENTION

The system, in which a cell is housed in a plastic coiled tube and the heat of the cell is retained by applying hot air to the inside of the tube using a hot air generator, has an advantage in that there is no effect caused by a magnetic field because, unlike with a heater, the heat of the cell is retained not by an electric action. However, because of heating being performed indirectly, it requires a long time to bring the cell to a desired temperature. Also, alkali metal atoms enclosed in the cell

adhere to the irradiation light passing-through parts of the cell because of the temperature difference between the irradiation light passing-through parts and the parts of the cell that are in contact with the tube, hindering the passage of the irradiation light. Furthermore, there are problems, for example, in that the periphery of the cell becomes large because thermal insulation is provided to the tube to prevent a temperature decrease.

The system, in which a transparent film heater is provided to the parts through which irradiation light applied to a cell passes and current is applied to the transparent film heater, thereby retaining the heat of the cell, has an advantage in that the cell is brought to a desired temperature more quickly, compared to the aforementioned heating technique using hot air in a tube. However, the magnetostatic field applied to the cell varies due to the effect of a magnetic field from the heater, lowering the accuracy of magnetic field measurement. Also, there are problems, for example, in that although the cell has been brought to a desired temperature, the fluctuation of the current value becomes large even though current applied to the heater is controlled, because the periphery of the cell is not thermally-insulated.

The system, in which hot air is applied to the inside of an oven housing a cell using a hot air generator to fill that container with hot air, thereby retaining the heat of the cell, has an advantage in that there is no effect of a magnetic field because, unlike with a heater, the heating is performed not by an electric action. Also, because the cell is heated directly in a hermetically sealed state, it has smaller temperature variations and is more quickly brought to a desired temperature compared to the aforementioned technique using hot air in a tube. However, irradiation light, which passes through the cell, wavers by the hot air, causing a problem in that the S/N ratio of the irradiation light that has passed through the cell, which is detected when performing magnetic measurement, may greatly deteriorate. Also, because of the use of hot air, the system becomes large as a result of thermal insulation provided to a hose from the cell to the hot air generator. The above problems also apply to the system in which hot air is applied using a hot air generator to the inside of a magnetic shielding provided to suppress environmental magnetic noise coming into a cell to fill the magnetic shielding with hot air, thereby retaining the heat of the cell.

The system, in which a c-field control circuit and a heater coil control-equipped control circuit are prepared and a c-field coil wound on a cavity housing a cell is used as a heater by means of a coil function switch device, thereby retaining the heat of the cell, has advantages in quick response to reach a desired temperature because of the use of a heater, and no effect of a magnetic field from a heater because of the use of a switch device. However, when using the coil as a heater, an accurate temperature cannot be obtained by measuring the outer side of the coil because a temperature increase in a coil exhibits a fairly large temperature gradient from the inner portion toward the outer portion. Also, a part of the cavity is heated using a heat transistor after the current applied to the heater coil is turned off, causing problems, for example, in that temperature variations occurs in the cell.

The system, in which a film heater is provided to a c-field coil wound on a cavity housing a cell, or a cell, and current is applied to the film heater, thereby retaining the heat of the cell, has advantages in quick response to reach a desired temperature because of the use of a heater, and smaller temperature variations in the cell compared to the aforementioned technique using a heater coil. However, the magneto-