MICROVALVE HAVING MAGNETIC WAX PLUG AND FLUX CONTROL METHOD USING MAGNETIC WAX

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

This application claims the benefit of Korean Patent Application No. 10-2005-0027829, filed on Apr. 2, 2005, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a microvalve and a microchip having a micro fluidic structure, and more particularly, to a bi-stable and phase change type microvalve provided in a micro fluidic structure and a microchip including the microvalve.

2. Description of the Related Art

In general, a valve refers to an apparatus that is connected to a pipe to control the amount of flow or pressure of a fluid. A microvalve and other apparatuses comprising a microvalve related to a micro fluidic structure have received wide attention, particularly in a bio-chemical field including a micro total analysis system (μTAS). The microvalve is widely used not only in the μTAS related to the development of new medicines, a clinical diagnosis system, and a biomedical research field such as a DNA, but also in an inkjet print field.

The microvalve developed with the development of a micro-electromechanical system (MEMS), or a so-called MEMS valve, has a important role in the micro fluidic structure with a micropump, as an important device having functions of allowing, limiting, and blocking the flow of a fluid including gas or liquid. The microvalves manufactured using a fine processing technology have a variety of structures and sizes from several micrometers to about 1 mm according to the type of driving and purpose.

A phase change valve has been studied among the various types of microvalves. The phase change valve refers to a tangible valve that is included in the micro fluidic structure to exist in a solid state and controls the flow of a fluid in a mode. The state of the phase change valve is changed from the solid state to a liquid state, causing a displacement or deformation, when the mode is changed to another mode. U.S. Pat. No. 6,679,279 and U.S. Patent Publication No. 2004-0219732 disclose the above phase change valve. A conventional phase change valve is described below with reference to FIGS. **1**A, **1**B, **2**A, and **2**B.

FIGS. **1**A and **1**B show an example of the conventional phase change valve, in which FIG. **1**A shows a closed mode in which a channel is closed and FIG. **1**B shows an open mode in which the channel is open. Referring to FIGS. **1**A and **1**B, a microchannel **21** is formed in a substrate **20**. A well **22** is formed at a side of the channel **21**. A solid wax plug **40** is provided in the microchannel **21** at the upper stream thereof with respect to the well **22**. A solid wax is a material which exists in a solid state at the room temperature and its fluidity grows as it is heated. A typical material for the solid wax is paraffin wax.

A heating portion **30** capable of selectively radiating heat is provided around the solid wax plug **40**. When the heating portion **30** radiates heat in the state as shown in FIG. **1**A, the solid wax plug **40** is melt. A melt wax **40'** flows into the well **22** by the pressure of a fluid flowing in the microchannel **21** and becomes solid in the well **22**. However, since the mode change of the conventional phase change valve **101** is irreversible, once the valve opens, the valve cannot be reused.

FIGS. **2**A and **2**B show another example of the conventional phase change valve. Referring to FIGS. **2**A and **2**B, a phase change valve **102** has a Y shaped connection portion where an inlet portion **23**, an outlet portion **24**, and a vent portion **25** meet. A heating portion **30** is provided a portion extending from the Y shaped connection portion to the vent portion **25**. As shown in FIG. **2**A, when the valve **102** is in an open mode, a solid wax plug **42** is located in the Y shaped connection portion. When the valve **102** is in a closed mode as shown in FIG. **2**B, the solid wax plug **42** is moved to the vent portion **25**.

For mode change, the solid wax plug **42** is melt using the heating portion **30** and a melted wax is moved by an air pressure and vacuum chamber (or pump) that is selectively connected to a side of the vent portion **25**. Thus, this type of the valve **102** needs a connection to a high pressure or vacuum chamber (or pump) using another valve for the driving of the valve. To facilitate miniaturization of the valves in units of micrometers and provide a micro fluidic structure which can be reused, the above disadvantages that the conventional phase change valves **101** and **102** have must be overcome.

SUMMARY OF THE INVENTION

To solve the above and/or other problems, the present invention provides a microvalve which requires the minimum number of additional parts for valve driving microvalve and can be reused by a reversible mode change.

The present invention provides a microchip having a micro fluidic structure to which the microvalve is applied.

According to an aspect of the present invention, a microvalve having a magnetic wax plug comprises a micro fluidic structure having an inlet portion and an outlet portion, a magnetic wax plug provided at a predetermined section where the inlet portion and the outlet portion meet, existing in a solid state, melted at a temperature higher than a predetermined temperature, and reversibly moving along a magnetic field, so as to control flux of a fluid through the micro fluidic structure, a heating portion provided corresponding to the section and heating the magnetic wax plug to be melted, and a magnetic field application portion selectively applying a magnetic field to a position where the melted magnetic wax plug arrives.

According to another aspect of the present invention, a microchip using a magnetic wax which performs a chemical reaction test with a small amount of a liquid test material using a micro fluidic structure formed on a substrate comprises a micro fluidic structure having a fine channel through which the liquid test material passes, and a magnetic wax member provided at a predetermined section of the micro fluidic structure, existing in a solid state, melted at a temperature higher than a predetermined temperature, and reversibly moving along a magnetic field, so as to control flux of a fluid through the micro fluidic structure.

According to another aspect of the present invention, a microchip unit using a magnetic wax including a microchip which performs a chemical reaction test with a small amount of a liquid test material using a micro fluidic structure formed on a substrate and a driving apparatus portion accommodating and driving the microchip comprises a micro fluidic structure having a fine channel through which the liquid test material passes, and a magnetic wax member provided at a predetermined section of the micro fluidic structure, existing in a solid state, melted at a temperature higher than a predetermined temperature, and reversibly moving along a mag-