nate of the cartridge, and recover an amount—typically about 1.5 microliter—of PCR product. The user may also place the individual PCR lane on a special narrow heated plate, maintained at a temperature to melt the wax in the valve, and then aspirate the reacted sample from the inlet hole of that PCR lane.

[0153] In various embodiments, the microfluidic network can optionally include at least one reservoir configured to contain waste.

[0154] Table 1 outlines typical volumes, pumping pressures, and operation times associated with various components of a microfluidic cartridge described herein.

TABLE 1

Operation	Pumping Pressure	Displacement Volume	Time of Operation
Moving valve wax plugs	~1-2 psi	<1 μl	5-15 seconds
Operation	**Pump Used**	**Pump Design**	**Pump Actuation**
Moving valve wax plugs	Thermopneumatic pump	1 μl of trapped air	Heat trapped air to ~70-90 C.

Valves

[0155] A valve (sometimes referred to herein as a microvalve) is a component in communication with a channel, such that the valve has a normally open state allowing material to pass along a channel from a position on one side of the valve (e.g., upstream of the valve) to a position on the other side of the valve (e.g., downstream of the valve). Upon actuation of the valve, the valve transitions to a closed state that prevents material from passing along the channel from one side of the valve to the other. For example, in one embodiment, a valve can include a mass of a thermally responsive substance (TRS) that is relatively immobile at a first temperature and more mobile at a second temperature. The first and second temperatures are insufficiently high to damage materials, such as polymer layers of a microfluidic cartridge in which the valve is situated. A mass of TRS can be an essentially solid mass or an agglomeration of smaller particles that cooperate to obstruct the passage when the valve is closed. Examples of TRS's include a eutectic alloy (e.g., a solder), wax (e.g., an olefin), polymers, plastics, and combinations thereof. The TRS can also be a blend of variety of materials, such as an emulsion of thermoelastic polymer blended with air microbubbles (to enable higher thermal expansion, as well as reversible expansion and contraction), polymer blended with expancel material (offering higher thermal expansion), polymer blended with heat conducting microspheres (offering faster heat conduction and hence, faster melting profiles), or a polymer blended with magnetic microspheres (to permit magnetic actuation of the melted thermoresponsive material).

[0156] Generally, for such a valve, the second temperature is less than about 90° C. and the first temperature is less than the second temperature (e.g., about 70° C. or less). Typically, a chamber is in gaseous communication with the mass of TRS. The valve is in communication with a source of heat that can be selectively applied to the chamber of air and to the TRS. Upon heating gas (e.g., air) in the chamber and heating the mass of TRS to the second temperature, gas pressure within the chamber due to expansion of the volume of gas, forces the mass to move into the channel, thereby obstructing material from passing therealong.

[0157] An exemplary valve is shown in FIG. **19**A. The valve of FIG. **19**A has two chambers of air **1203**, **1205** in contact with, respectively, each of two channels **1207**, **1208** containing TRS. The air chambers also serve as loading ports for TRS during manufacture of the valve, as further described herein. In order to make the valve sealing very robust and reliable, the flow channel **1201** (along which, e.g., sample passes) at the valve junction is made narrow (typically 150 μm wide, and 150 μm deep or narrower), and the constricted portion of the flow channel is made at least 0.5 or 1 mm long such that the TRS seals up a long narrow channel thereby reducing any leakage through the walls of the channel. In the case of a bad seal, there may be leakage of fluid around walls of channel, past the TRS, when the valve is in the closed state. In order to minimize this, the flow channel is narrowed and elongated as much as possible. In order to accommodate such a length of channel on a cartridge where space may be at a premium, the flow channel can incorporate one or more curves **1209** as shown in FIG. **19**A. The valve operates by heating air in the TRS-loading port, which forces the TRS forwards into the flow-channel in a manner so that it does not come back to its original position. In this way, both air and TRS are heated during operation.

[0158] In various other embodiments, a valve for use with a microfluidic network in a microfluidic cartridge herein can be a bent valve as shown in FIG. **19**B. Such a configuration reduces the footprint of the valve and hence reduces cost per part for highly dense microfluidic cartridges. A single valve loading hole **1211** is positioned in the center, that serves as an inlet for thermally responsive substance. The leftmost vent **1213** can be configured to be an inlet for, e.g., sample, and the rightmost vent **1215** acts as an exit for, e.g., air. This configuration can be used as a prototype for testing such attributes as valve and channel geometry and materials.

[0159] In various other embodiments, a valve for use with a microfluidic network can include a curved valve as shown in FIG. **19**C, in order to reduce the effective cross-section of the valve, thereby enabling manufacture of cheaper dense microfluidic devices. Such a valve can function with a single valve loading hole and air chamber **1221** instead of a pair as shown in FIG. **19**A.

Gates

[0160] FIG. **19**D shows an exemplary gate as may optionally be used in a microfluidic network herein. A gate can be a component that can have a closed state that does not allow material to pass along a channel from a position on one side of the gate to another side of the gate, and an open state that does allow material to pass along a channel from a position on one side of the gate to another side of the gate. Actuation of an open gate can transition the gate to a closed state in which material is not permitted to pass from one side of the gate (e.g., upstream of the gate) to the other side of the gate (e.g., downstream of the gate). Upon actuation, a closed gate can transition to an open state in which material is permitted to pass from one side of the gate (e.g., upstream of the gate) to the other side of the gate (e.g., downstream of the gate).

[0161] In various embodiments, a microfluidic network can include a narrow gate **380** as shown in FIG. **19**D where a gate loading channel **382** used for loading wax from a wax loading hole **384** to a gate junction **386** can be narrower (e.g., approximately 150 μm wide and 100 microns deep). An upstream