502 has an active cooling system, which is used to restore the expanded shape of thermal fluid pocket **504** to its original shape after it is deactivated. The control of fluid temperature affects haptic bandwidth. Rapid rising of fluid temperature and fast heat dissipation of fluid enhance haptic bandwidth of thermal fluid packets.

[0079] The physical size of each fluid cell **502** can also affect the performance of the cell for generating haptic sensation(s). For example, if the size of fluid cell **504** is smaller than ½ fingertip, the performance of cell **504** enhances because smaller cell permits rapid heat dissipation as well as quick temperature rising of fluid in the cell. In another embodiment, thermal plastic pockets filled with plastic fluid are used in place of thermal fluid pockets **504** filled with thermally sensitive fluid to enhance the haptic effects. Using thermal plastic pockets filled with plastic-like fluid can produce high thermal plastic strain. For example, a type of plastic fluid is polyethylene. Thermal plastic pockets can also provide different and unique haptic sensations to the user. In another embodiment, some exotic fluids such as electrorheological and/or magnetorheological fluid can be used in place of thermal fluid in thermal fluid pockets **504**. Thermal fluid pockets **504** filled with electrorheological fluid can be stimulated by a local or remote electrical field, while thermal fluid pockets **504** filled with magnetorheological fluid can be stimulated by a local or remote magnetic field.

[0080] FIG. **5**(*b*) is a side view diagram for an interface device **550** illustrating an array of haptic cells **502** using thermal fluid pockets **554** in accordance with one embodiment of the present invention. Device **550** also shows an activated thermal fluid pocket **554** and an activated activating cell **560**. During the operation, thermal fluid pocket **554** increases its physical volume (or size) from its original state **556** to expanded thermal fluid pocket **554** when activating cell **560** is activated. When activating cell **560** is activated, it provides heat **562** to thermal fluid pocket **554** or **556** to expand the size of thermal fluid pocket **554** or **556**. Due to the expansion of thermal fluid pocket **554**, a localized portion **552** of insulated layer **506** is created. As soon as the temperature of the fluid in the thermal fluid pocket **554** cools down, the size of thermal fluid pocket **554** returns to its original state **556**. The change of size between original size of a thermal fluid pocket **556** and expanded size of thermal fluid pocket **554** generates a haptic effect. It should be noted that activating cell **560** could be an electric heater or an optical heater such as an infrared simulator. As such, an array of haptic cells using thermal fluid pockets **552** may be used to control the surface texture of touch-sensitive surface of the interface device.

[0081] FIG. **6**(*a*) is a side view diagram of an interface device **600** illustrating an array of MEMS pumps **602** in accordance with one embodiment of the present invention. The array of MEMS pumps **602** can be used to implement tactile regions for controlling surface textures. Diagram **600** includes an insulated layer **606** and a haptic layer **612**. While the top surface of insulated layer **606** is configured to receive a touch or touches from a user, the bottom surface of insulated layer **606** is placed adjacent to the top surface of haptic layer **612**. The bottom surface of haptic layer **612** is, in one embodiment, placed adjacent to a display (not shown in FIG. **6**(*a*)), wherein haptic layer **612** and insulated layer **606** may be substantially transparent thereby objects or images displayed in the display can be seen through haptic layer **612** and insulated layer **606**. It should be noted that display is not a necessary component in order for the interface device to function.

[0082] Haptic layer **612**, in one embodiment, includes a grid of MEMS pumps **602**, which further includes at least one pocket **604**. Each MEMS pump **602** includes a pressurized valve **608** and a depressurized valve **610**. Pressurized valve **608** is coupled to an inlet tube **614** while depressurized valve **610** is coupled to an outlet tube **616**. In one embodiment, inlet tube **614**, which is under high liquid pressure, is used to pump liquid through pressurized valve **608** to expand pocket **604**. Similarly, outlet tube **616**, which is under low pressure, is used to release the liquid through depressurized valve **610** to release the pressure from pocket **604**. In one embodiment, MEMS pumps **602** can be coupled to the same pressurized liquid reservoir. In addition, pressurized valve **608** and depressurized valve **610** may be combined into one single valve for both inlet tube **614** and outlet tube **616**. It should be noted that inlet tube **614** and outlet tube **616** can also be combined into one tube.

[0083] A grid of MEMS pumps **602** includes an array of pressurized valves **608** and depressurized valves **610**, wherein pressurized valves **608** are coupled with a rear or a side mounted liquid reservoir under pressure while depressurized valves **610** are coupled to a rear or a side mounted depressurized liquid reservoir with low pressure. Valves **608-610** control the filling and emptying the liquid pockets **604** in MEMS pumps **602** to produce localized strain. An advantage of using pressurized liquid reservoir is to quickly deform the surface of insulated layer **606** and to maintain the deformation with minimal or no energy consumption (or expenditure). It should be noted that MEMS pump **602** can also use pressurized air or other gases to achieve similar results as liquid.

[0084] Device **600** further includes a set of control wires **617-618**, which can be used to control pressurized valve **608** and depressurized valve **610**, respectively. It should be noted that each valve in haptic layer **612** is addressable using electrical signals transmitted from wires or wireless network.

[0085] FIG. **6**(*b*) illustrates two diagrams of an interface device **620** and **650** having an array of MEMS pumps **604** in accordance with one embodiment of the present invention. Device **620** illustrates an activated pocket **623**, which includes an activated inlet valve **630** and a deactivated outlet valve **632**. During an operation, pocket **623** increases its physical volume (or size) from its original state **624** to its expanded pocket **623** when inlet valve **630** is activated. When inlet valve **630** is activated (or open) in response to electrical signal from wire **628**, inlet tube **625** pumps liquid **626** from pressurized reservoir to pocket **623**. Due to the expansion of pocket **623**, a localized strain **622** of insulated layer **606** is created.

[0086] Device **650** illustrates an activated MEMS pump returns from its expanded state of pocket **623** to the original state of pocket **653**. When depressurized valve **660** is activated, depressurized valve **660** releases liquid **656** from pocket **653** to low pressurized outlet **654**. It should be noted that depressurized valve **660** is controlled by at least one control signal via wire **658**. The change in volume between original size of pocket **604** and expanded size of pocket **623** generates haptic effects. As such, an array of MEMS pumps **602** may be used to control the surface texture of touch-sensitive surface of the interface device.

[0087] FIG. **7** illustrates a side view diagram for an interface device **700** having an array of haptic cells **702** using variable porosity membrane **710** in accordance with one