accordance with an ambient temperature and/or surrounding environment. It should be noted that the present invention may combine piezoelectric elements, cantilever-spring, and/or SMA to achieve a specific haptic sensation. As such, a grid of MEMS device **402** may be used to control the surface texture of touch-sensitive surface of the interface device.

[0057] FIG. **5**(*a*) is a side view diagram of an interface device **500** illustrating an array of haptic cells **502** with thermal fluid pockets **504** in accordance with one embodiment of the present invention. Device **500** includes an insulated layer **506**, a haptic layer **512**, and a display **508**. While the top surface of insulated layer **506** is capable of receiving inputs from a user, the bottom surface of insulated layer **506** is placed adjacent to the top surface of haptic layer **512**. The bottom surface of haptic layer **512** is placed adjacent to display **508**, wherein haptic layer **512** and insulated layer **506** may be substantially transparent thereby objects or images displayed in display **508** can be seen through haptic layer **512** and insulated layer **506**. It should be noted that display **508** is not a necessary component in order for the interface device to function.

[0058] Haptic layer **512**, in one embodiment, includes a grid of fluid filled cells **502**, which further includes at least one thermal fluid pocket **504** and an associated activating cell **510**. It should be noted that each of fluid filled cells **502** can include multiple thermal fluid pockets **504** and associated activating cells **510**. In another embodiment, a fluid filled cell **502** includes multiple associated or shared activating cells **510** thereby initiating a different activating cell generates a different haptic sensation(s).

[0059] Activating cell **510**, in one embodiment, is a heater, which is capable of heating an associated thermal fluid pocket **504**. Various electrical, optical, and mechanical techniques relating to heating technology can be used to fabricate activating cells **510**. For example, various electrically controlled resistors can be used for activating cells **510**, wherein resistors can be implanted in haptic layer **512** during the fabrication. Alternatively, optical stimulators such as infrared lasers can be used as activating cells **510** to heat up thermal fluid pockets **504**. Optical stimulator, for example, can be mounted at the edge of the interface device. It should be noted that activating cells **510** can be any types of optical or radioactive stimulator as long as it can perform the function of a heating device. Activating cells **510** may also use rear mounted thermal stimulators, which are similar technologies like hot plasma displays such as are commonly found in flat panel plasma televisions.

[0060] Device **500** further includes a set of control wires, not shown in FIG. **5**(*a*), wherein each of activating cells **510** is coupled to at least one pair of wires. The wires are configured to transmit activating/deactivating control signals, which are used to drive activating cells **510**. It should be noted that each of fluid filled cells **502** is addressable using signals from wires or wireless networks. Display **508**, in one aspect, can be a flat panel display or a flexible display. In an alternative embodiment, the physical location of display **508** is exchangeable with haptic layer **512**. Also, thermal fluid pockets **504**, in one embodiment, can be activated by a piezoelectric grid.

[0061] Thermal fluid pockets **504**, in one embodiment, include fluid with physical properties of low specific heat and high thermal expansion. Examples of this fluid include glycerin, ethyl alcohol, or the like. Thermal fluid pockets **504** are capable of producing multiple localized strains in response to multiple touches received by insulated layer **506**. Each localized strain is created by a heated thermal fluid pocket **504** wherein the heat is generated by an associated activating cell **510**. In one embodiment, a thermal fluid pocket **504** changes its physical shape in accordance with the temperature of the fluid in the pocket. In another embodiment, fluid filled cell **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.

[0062] 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.

[0063] 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.

[0064] 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. 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