for a period of time after the voltage potential is removed. It should be noted that the underlying concept of the embodiments of the present invention does not change if different materials other than piezoelectric actuators are employed. As such a grid of piezoelectric actuators may be used to control the surface texture of touch-sensitive surface of the interface device.

[0070] FIG. **4**(*c*) is a diagram **450** illustrating another embodiment of a tactile or haptic region or cell **410** using MEMS device **452** to generate haptic effects in accordance with one embodiment of the present invention. Diagram **450** depicts a block **460**, which shows a top view of cell **410**. Cell **410** includes a MEMS device **452**. In one embodiment, MEMS device **452** is substantially transparent thereby the image projection from a display, not shown in FIG. **4**(*c*), can be viewed through block **460**. It should be noted that each of haptic cells **410** is coupled to at least one wire to facilitate and generate haptic effects.

[0071] MEMS can be considered as an integration of mechanical devices, sensors, and electronics on a silicon or organic semiconductor substrate, which can be manufactured through conventional microfabrication process. For example, the electronic devices may be manufactured using semiconductor fabrication process and micromechanical devices may be fabricated using compatible microfabrication process. In one embodiment, a grid or an array of MEMS devices **452** are made of multiple cantilever-springs. A grid of cantilever-springs can be etched using MEMS manufacturing techniques. Also, electrical wirings for stimulating or driving cantilever-springs can also be directly etched onto the surface of the MEMS device **452** thereby every single MEMS device can be correctly addressed. MEMS cantilevers can be stimulated using a resonant drive (for vibrotactile) or direct actuation (kinesthetic).

[0072] FIG. **4**(*d*) illustrates a side view of MEMS device **452**, wherein MEMS device **462** can be stimulated or deformed from its original state of MEMS device **452** to deformed state of MEMS device **464** when a voltage potential across MEMS device is applied. Displacement **454** between the original state and the deformed state depends on the composition of materials used and the size of MEMS device **452**. Although smaller MEMS devices **452** are easier to fabricate, they offer smaller displacement **454**. In one embodiment, cantilever-springs can be made of piezo materials. It should be noted that the actuation of piezo material is generally vibrotactile sensation. It should be further noted that piezo material can be used as a sensor for sensing fingertip positions and depressions.

[0073] MEMS device **452**, in another embodiment, uses SMA in place of cantilever-spring as mentioned above. The actuation generated by MEMS device **452** using SMA provides kinesthetic actuation. SMA, also known as memory metal, could be made of copper-zinc-aluminum, copper-aluminum-nickel, nickel-titanium alloys, or a combination of copper-zinc-aluminum, copper-aluminum-nickel, and/or nickel-titanium alloys. Upon deforming from SMA's original shape, SMA regains its original shape in 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 **452** may be used to control the surface texture of touch-sensitive surface of the interface device.

[0074] FIG. **5**(*a*) is a side view diagram of an interface device **500** illustrating an array of haptic cells or tactile region **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.

[0075] 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).

[0076] 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 include rear mounted thermal stimulators, which are similar technologies like hot plasma displays such as are commonly found in flat panel plasma televisions.

[0077] 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.

[0078] 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