EAP, also known as biological muscles or artificial muscles, is capable of changing its shape in response to an application of voltage. The physical shape of an EAP may be deformed when it sustains large force. EAP may be constructed from Electrostrictive Polymers, Dielectric elastomers, Conducting Polyers, Ionic Polymer Metal Composites, Responsive Gels, Bucky gel actuators, or a combination of the above-mentioned EAP materials.

[0031] SMA (Shape Memory Alloy), also known as memory metal, is another type of material which can be used to construct haptic substrate **104**. SMA may 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. A characteristic of SMA is that when its original shape is deformed, it regains its original shape in accordance with the ambient temperature and/or surrounding environment. It should be noted that the present embodiment may combine the EAP, piezoelectric elements, and/or SMA to achieve a specific haptic sensation.

[0032] Deforming mechanism **106** provides a pulling and/or pushing force to translate elements in the haptic substrate **104** causing flexible surface **102** to deform. For example, when deforming mechanism **106** creates a vacuum between flexible surface **102** and haptic substrate **104**, flexible surface **102** is pushed against haptic substrate **104** causing flexible surface **102** to show the texture of flexible surface **102** in accordance with the surface pattern of haptic substrate **104**. In other words, once a surface pattern of haptic substrate **104** is generated, flexible surface is pulled or pushed against haptic substrate **104** to reveal the pattern of haptic substrate **104** through the deformed surface of flexible surface **102**. In one embodiment, haptic substrate **104** and deforming mechanism **106** are constructed in the same or substantially the same layer.

[0033] Upon receipt of a first activating signal, haptic substrate **104** generates a first surface pattern. After formation of the surface pattern of haptic substrate **104**, deforming mechanism **106** is subsequently activated to change surface texture of flexible surface **102** in response to the surface pattern of haptic substrate **104**. Alternatively, if haptic substrate **104** receives a second activating signal, it generates a second pattern.

[0034] Haptic substrate **104** further includes multiple tactile regions wherein each region can be independently activated to form a surface pattern of the substrate. Haptic substrate **104** is also capable of generating a confirmation feedback to confirm an input selection entered by a user. Deforming mechanism **106** is configured to deform the surface texture of flexible surface **102** from a first surface characteristic to a second surface characteristic. It should be noted that haptic device further includes a sensor, which is capable of activating the device when the sensor detects a touch on flexible surface **102**. Deforming mechanism **106** may be a vacuum generator, which is capable of causing flexible surface **102** to collapse against the first surface pattern to transform its surface configuration in accordance with the configuration of first pattern of haptic substrate **104**.

[0035] FIG. **1**(*b*) shows a 3D diagram illustrating a haptic device **130** using a haptic substrate and a flexible surface in accordance with one embodiment of the present invention. Device **130** includes a flexible surface **102**, a haptic substrate **134**, and a deforming mechanism **106**. It should be noted that the underlying concept of the exemplary embodiment of the present invention would not change if additional blocks (circuits or layers) were added to or removed from device **130**.

[0036] Haptic substrate **134** is similar or substantially similar to haptic substrate **104** illustrated in FIG. **1**(*a*) except that tactile regions **136** and **139** are activated. Tactile regions **136** and **139** are raised in a z-axis direction. Upon receipt of one or more activating signals, haptic substrate **134** identifies a surface pattern in accordance with the activating signals. Haptic substrate **134** provides identified pattern by activating various tactile regions such as regions **136** and **139** to generate the pattern. It should be noted that tactile regions **136** and **139** imitate two buttons or keys. In another embodiment, tactile region **136** or **139** includes multiple haptic bits wherein each bit can be controlled for activating or deactivating.

[0037] FIG. **1**(*c*) shows a 3D diagram illustrating a haptic device **140** using a haptic substrate and a flexible surface in accordance with one embodiment of the present invention. Device **140** includes a flexible surface **142**, a haptic substrate **134**, and a deforming mechanism **106**. It should be noted that haptic substrate **134** and deforming mechanism **106** are the same or substantially the same elements. It should be further noted that the underlying concept of the exemplary embodiment of the present invention would not change if additional blocks were added to or removed from device **140**.

[0038] When deforming mechanism **106** is activated, flexible surface **142** collapses over haptic substrate **134**, which, as illustrated in FIG. **1**(*b*), has two activated tactile regions **136** and **139**, to form two bumps **156** and **159**. Bumps **156** and **159**, in one example, imitate two buttons. For example, haptic substrate **134** is capable of detecting a contact on button **156** or **159** and providing a haptic feedback to confirm which button had been depressed. Alternatively, haptic substrate **134** is capable of generating one of many unique physical patterns in response to one or more signals. As such, flexible surface **102** can be reconfigured to different patterns in accordance with the pattern or patterns provided by haptic substrate **134**. The surface texture of flexible surface can be configured to a telephone key pad, a calculator buttons, computer key pad, radio panel, PDA interfaces, or the like.

[0039] FIG. **1**(*d*) shows examples of haptic substrates **150-170** illustrating different patterns generated by haptic effect in accordance with one embodiment of the present invention. Substrate **150** illustrates an array of tactile regions **152** wherein each region can be independently controlled and activated. Substrate **160** illustrates that nine (9) tactile regions **162** situated in the mid-section of substrate **160** are activated and raised. Also, two sections **172-174** of haptic substrate **170** have been raised to provide a different surface pattern. It should be noted that various different patterns can be generated from the array of tactile regions in response to the various control signals. It should be further noted that substrate can change over time, which causes flexible surface **102** to change as well.

[0040] FIG. **1**(*e*) illustrates a haptic device **180** using haptic substrates and flexible surfaces in accordance with one embodiment of the present invention. Device **180** includes a flexible screen and an array of actuator **186** wherein the flexible screen is capable of combining haptic sensation with computer graphics. The flexible screen, for example, illustrates the terrain and/or texture of a mountain **182** as well as a watery sensation or texture of a lake **184**. When a computer displays a graphical representation of a mountain terrain and a lake, device **180** provides realistic sensation of mountain terrain for the mountain and watery texture for the lake. For