[0020] FIG. **9** is a flowchart illustrating a process of providing haptic textures on a deformable haptic surface in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION

[0021] Exemplary embodiments of the present invention are described herein in the context of a method, system and apparatus for providing haptic surface texture on a flexible surface.

[0022] Those skilled in the art will realize that the following detailed description of the exemplary embodiment(s) is illustrative only and is not intended to be in any way limiting. Other embodiments will readily suggest themselves to such skilled persons having the benefit of this disclosure. Reference will now be made in detail to implementations of the exemplary embodiment(s) as illustrated in the accompanying drawings. The same reference indicators will be used throughout the drawings and the following detailed description to refer to the same or like parts.

[0023] In the interest of clarity, not all of the routine features of the implementations described herein are shown and described. It will, of course, be appreciated that in the development of any such actual implementation, numerous implementation-specific decisions must be made in order to achieve the developer's specific goals, such as compliance with application- and business-related constraints, and that these specific goals will vary from one implementation to another and from one developer to another.

[0024] A user interface device having a haptic textured surface over a deformable surface layer using various haptic actuators is disclosed. The device includes a flexible surface layer, a haptic substrate, and a deforming mechanism. The flexible surface layer, for instance, is made of soft and/or elastic material, which is capable of changing its surface configuration from one texture (i.e., haptic substrate) to another texture. The haptic substrate, in one embodiment, provides a first pattern in response to a first activating signal. Alternatively, the haptic substrate can provide a second pattern in accordance with a second activating signal. The deforming mechanism is used to change the texture of the flexible surface from a first surface characteristic to a second surface characteristic.

[0025] FIG. **1**(*a*) shows a three-dimensional (3D) diagram illustrating a haptic device **100** using a haptic substrate and a flexible surface in accordance with one embodiment of the present invention. Device **100** includes a flexible surface layer **102**, a haptic substrate **104**, and a deforming mechanism **106**. It should be noted that device **100** can be a user interface device, such as an interface for a cellular phone, a personal digital assistant ("PDA"), an automotive data input system, and so forth. It should be further noted that the underlying concept of the exemplary embodiment of the present invention would not change if one or more blocks (circuits or layers) were added to or removed from device **100**.

[0026] Flexible surface layer **102**, in one instance, is made of soft and/or elastic materials such as silicone rubber, which is also known as polysiloxane. A function of the flexible surface layer **102** is to change its surface shape or texture upon contact with the physical pattern of haptic substrate **104**. The physical pattern of haptic substrate **104** is variable as one or more of the local features **110**-**124** can be raised or lowered to present features to affect the surface of the flexible surface layer **102** upon contact. Once the physical pattern of haptic substrate **104** is determined, the texture of flexible surface layer **102** can change to confirm its surface texture to the physical pattern of haptic substrate **104**. It should be note that the deformation of flexible surface layer **102** from one texture to another can be controlled by deforming mechanism **106**. For example, when deforming mechanism **106** is not activated, flexible surface layer **102** maintains its smooth configuration floating or sitting over haptic substrate **104**. The surface configuration of flexible surface layer **102**, however, deforms or changes from a smooth configuration to a coarse configuration when deforming mechanism **106** is activated and the haptic substrate **104** is in contact with the flexible surface layer **102** so as to generate a similar pattern on the top surface of the flexible surface layer **102**.

[0027] Alternatively, flexible surface layer **102** is a flexible touch sensitive surface, which is capable of accepting user inputs. The flexible touch sensitive surface can be divided into multiple regions wherein each region of the flexible touch sensitive surface can accept an input when the region is being touched or depressed by a finger. In one embodiment, the flexible touch sensitive surface includes a sensor, which is capable of detecting a nearby finger and waking up or turning on the device. Flexible surface layer **102** may also include a flexible display, which is capable of deforming together with flexible surface layer **102**. It should be noted that various flexible display technologies can be used to manufacture flexible displays, such as organic light-emitting diode (OLED), organic, or polymer TFT (Thin Film Transistor).

[0028] Haptic substrate **104** is a surface reconfigurable haptic device capable of changing its surface pattern in response to one or more pattern activating signals. Haptic substrate **104** can also be referred to as a haptic mechanism, a haptic layer, a tactile element, and the like. Haptic substrate **104**, in one embodiment, includes multiple tactile or haptic regions **110**-**124**, wherein each region can be independently controlled and activated. Since each tactile region can be independently activated, a unique surface pattern of haptic substrate **104** can be composed in response to the pattern activating signals. In another embodiment, every tactile region is further divided into multiple haptic bits wherein each bit can be independently excited or activated or deactivated.

[0029] Haptic substrate **104**, or a haptic mechanism, in one embodiment, is operable to provide haptic feedback in response to an activating command or signal. Haptic substrate **104** provides multiple tactile or haptic feedbacks wherein one tactile feedback is used for surface deformation, while another tactile feedback is used for input confirmation. Input confirmation is a haptic feedback to inform a user about a selected input. Haptic mechanism **104**, for example, can be implemented by various techniques including vibration, vertical displacement, lateral displacement, push/pull technique, air/fluid pockets, local deformation of materials, resonant mechanical elements, piezoelectric materials, micro-electro-mechanical systems ("MEMS") elements, thermal fluid pockets, MEMS pumps, variable porosity membranes, laminar flow modulation, or the like.

[0030] Haptic substrate **104**, in one embodiment, is constructed by semi-flexible or semi-rigid materials. In one embodiment, haptic substrate should be more rigid than flexible surface **102** thereby the surface texture of flexible surface **102** can confirm to the surface pattern of haptic substrate **104**. Haptic substrate **104**, for example, includes one or more actuators, which can be constructed from fibers (or nanotubes) of electroactive polymers ("EAP"), piezoelectric elements, fiber of shape memory alloys ("SMAs") or the like.