

[0023] FIGS. 18a and 18b illustrate a cross sectional view of an embodiment employing a flexible sliding plate in accordance with one embodiment of the invention;

[0024] FIGS. 19 and 20 illustrate cross sectional views of another example of a gas expandable actuation structure and flexible skin structure in accordance with one example;

[0025] FIGS. 21 and 22 illustrate a perspective view of a portable electronic device with a deactivated and actuated controllable skin texture surface; and

[0026] FIGS. 23-25 illustrate a perspective view of a portable electronic device illustrating different portions of a controllable skin texture being actuated and deactivated in accordance with one example disclosed below.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0027] Briefly, a portable device includes a controllable skin texture surface that includes a skin texture surface actuation structure that includes a hydraulic actuation structure and a flexible skin structure that moves in response to movement of fluid to change a tactile configuration of at least a portion of the controllable skin texture surface. In one example, a substrate includes one or more fluid channels and the flexible skin structure includes a plurality of fluid pockets corresponding to texture features that are in fluid communication with at least one fluid channel. A fluid pump that moves the fluid in and out of the fluid passages may be controlled either by electronic control signals or mechanical movement of a movable housing portion.

[0028] In another example, a portable electronic device includes a controllable skin texture surface and control logic that is operative to change a tactile configuration of at least a portion of the controllable skin texture surface in response to at least any one (i.e., one or more) of: a received wireless signal, a battery level change condition, an incoming call or message, information from a proximity sensor, sound sensor, light sensor, accelerometer or other sensor that measures environmental conditions, data representing a user of the device, or data representing completion of a user authentication sequence. The portion of the controllable skin texture surface may be part of a non-user interface portion or a user interface portion, such as a function key, keypad or other operational element of the device.

[0029] The controllable skin texture surface may include a mechanical actuation structure that is coupled to a flexible skin texture, such as a polyurethane layer, rubber composite or any other suitable material that moves in response to movement of the mechanical actuation structure. The flexible skin structure may be affixed to a substrate including a portion of a device housing or any other suitable surface and may be formed by separate pieces or a unitary piece. The controllable skin texture surface may include a hydraulic actuation structure that is coupled to the flexible skin structure that moves in response to movement of fluid in the hydraulic actuation structure. In another example, the controllable skin texture surface may include an expandable gas actuation structure that is operatively coupled to a flexible skin structure that moves in response to movement of gas in the expandable gas actuation structure. Also if desired, the controllable skin texture surface may include a shape memory alloy actuation structure that is operatively coupled to a flexible skin structure that moves in response to movement of a metal alloy in the shape memory alloy actuation structure. Any desired combination of these different structures may also be used.

The controllable skin texture surfaces include a flexible skin structure that is raised or lowered to provide, for example, a raised feature (e.g., one or more skin texture elements) that can be tactically detected by a user or visually detected by a user if desired. Touch sensors, such as capacitive elements, dome key switches or other suitable elements may be used to detect when a user touches portions of the flexible surface such as non-raised or raised features, to correspond, for example, to a button press or similar functional input from the user or to actuate the controllable skin texture. It is also possible to place contact switches, such as dome-type switches known in the art, below the flexible skin structure so as to be actuated by the push of a user's finger.

[0030] In one example, the controllable skin texture surface is controlled to cause the controllable skin texture surface on the device to pulsate or otherwise change in a time-varying manner. In addition, other visual effects may be employed including providing lighting in addition to skin texture surface control to illuminate portions of the skin texture differently in response to different control conditions.

[0031] In one example, a portable electronic device employs a controllable skin texture surface that includes a mechanical skin texture surface actuation structure that includes a sliding element operative to cause movement of portions of the flexible skin structure. In one example, the sliding element is a movable ramp structure. The flexible skin structure moves in response to movement of the movable ramp structure to change a tactile configuration of at least a portion of the controllable skin texture surface. In another example, the sliding element is a flat flexible sliding element. The skin structure moves in response to movement of the sliding element to change a tactile configuration of at least a portion of the controllable skin texture surface.

[0032] In one example, the movable ramp structure includes a plurality of ramps either on a single plate or on multiple moving plates. A cam or rack & pinion structure may be linked with the plurality of ramps and controlled either electronically or mechanically, to move at least one of the plurality of ramps in response to an electronic control signal or mechanical movement of a portion of the device. Mechanical movement of a portion of the device may include by way of example, the moving of a flip portion of a flip phone or the cover of a laptop device. In another example, the movable ramp structure includes wedge shaped elements and a movable ramp structure that engages with the wedge shaped elements such that movement of the ramp structure causes movement of the wedge shaped elements and movement of the flexible skin texture to produce raised (or lowered) skin texture portions as the ramps are moved. A handheld wireless device is also disclosed that employs the above structures and also includes, a wireless telephone subsystem, display, and other conventional electronics and functionality in addition to the controllable skin texture surfaces described herein.

[0033] FIG. 1 illustrates one example of a portable electronic device 100, shown in this example to be a handheld wireless device, that includes a wireless telephone subsystem for communication via one or more suitable wireless networks, and other conventional circuitry along with a display 102 for displaying information to a user that is coupled to the wireless telephone subsystem as known in the art. The portable electronic device 100 also includes a controllable skin texture surface 104 that in this example, covers a portion of a housing (e.g., base housing) of the device 100 that forms part of a user interface portion, namely a user keypad. The con-