[0070] Exemplary Active Material HMI's, Applications, and Uses

[0071] As previously stated, it is intended that the modification of at least a portion of the interface **10** facilitates selection and manipulation by a human user **12** (FIG. **3**). That is to say, the invention facilitates discriminating and distinguishing the desired interface **10** from a plurality of interfaces **16** by offering a visibly and also tactilely distinct, and more preferably unique geometric shape, orientation, position or characteristic, in comparison to the other interfaces **16**. In FIGS. **1** and **1**A, for example, a plurality of cylindrical knobs **16** extend from the instrument panel **18** of a vehicle **20** and is coupled to a radio system **14**; to facilitate selection of interface **10**, selective modification to the enlarged distal configuration shown is caused. Moreover, where modification results from user action (e.g., manual activation, sensor detection (e.g., proximity, contact, pressure, etc.), user preference settings, voice command, etc.), the invention provides visual and tactile confirmation that the system **12** was properly selected. Finally, the preferred reconfigurable interface **10** also facilitates manual engagement by the user **14** by changing its geometric shape to one that is more readily manipulated by a human hand.

[0072] More particularly, and as shown in FIGS. **1**-**6**, the interface **10** includes or is drivenly coupled to at least one active material element **22** that acts as the actuator for modification. The element (or "actuator") **22** is comprised of an active material and therefore operable to undergo a reversible change in fundamental property when exposed to or occluded from an activation signal, as described above. In a preferred embodiment, the fundamental property change causes the element **22** to undergo a change in a dimension, e.g. due to the contraction or expansion of the element **22**, or in a characteristic of the element **22**, such as the spring constant or fluid shear strength thereof. The change in the elemental **22** causes the interface **10** to achieve a second geometric shape, position, orientation, and/or otherwise characteristic different from at least the adjacent interfaces **16** (FIG. **1**).

[0073] The element **22** is communicatively coupled to a source **24** that is operable to generate the activation signal in such a manner that the element **22** is selectively caused to be exposed to the signal. For example, in the automotive setting shown in FIGS. **1** and **1**A, the source **24** is presented by the charging system or battery of the vehicle **20**, and a thermal activation signal is selectively produced by passing a current through the resistance of the element **22**, so as to result in Joule heating.

[0074] More preferably, a controller **26** is intermediately coupled to the source **24** and element **22**, and programmably configured to control exposure to the signal by the element **22**. In this regard, it is appreciated that the interface **10** may be configured such that it reverts back to the original shape upon the discontinuance of the signal. To that end, a pseudoplastically strained SMA element **22** may be utilized. In this configuration, upon discontinuance of the thermal signal, the element **22** begins to cool, which works to return it back to the original martensitic state; moreover, it is appreciated that the strain in the element **22** works to accelerate transition to the martensitic state.

[0075] Alternatively, the element **22** may be configured such that the interface **10** is caused, when activated, to achieve a permanent second shape that is maintained even when the signal is terminated. The element **22** preferably presents "two-way" action, wherein returning to the original condition is caused by re-activation. In this configuration a suitable SMP, SMA, or MR elastomer may exemplarily be utilized. In yet another alternative, such as in the case of using SMA as the actuator element **22** (either in terms of its shape memory or superelastic properties) a latch or detent (not shown) may be caused to engage the interface **10** when modified, so as to provide a zero-power hold, and thereby eliminate the need for a constant signal to maintain the second shape, position, orientation or characteristic. The latch or detent may be released by a subsequent activation of the element **22**, or by a second actuator (not shown) coupled thereto. The second actuator may be electro-mechanically driven or may also utilize active material actuation.

[0076] Additionally, at least one sensor **28**, operable to detect a condition relative to or that typically triggers use of the system **14**, and generate a data signal based thereupon, is communicatively coupled, so as to send the data signal to the controller **26**. As further discussed below, the controller **26** is configured to selectively cause activation or deactivation only when the data signal is received. For example, the sensor **28** may be operable to detect moisture upon a windshield **30** of the vehicle **20**, and the interface **10***a* may be the windshield wiper control dial (FIG. **1**A). Here, the source **24**, sensor **28**, controller **26**, and wiper interface **10***a* may be cooperatively configured such that the interface **10***a* increases in diameter so as to raise from a surface cooperatively defined by a group of proximate dials.

[0077] In another example (shown in FIG. **1**) the sensor **28** may be a microphone operable to detect a voice command. In this configuration, the controller **26** is communicatively coupled to the microphone **28** and equipped with suitable voice recognition software, so as to be able to distinguish the directed command from other audible sounds. The controller **26** is configured to cause the interface **10** to be exposed to the signal only when the command is received.

[0078] Turning to the structural configuration of the interface **10**, FIG. **2**A presents a first embodiment, wherein the interface **10** is formed entirely of the active material. In this configuration the interface/element may be comprised of a suitable SMP. Alternatively, the interface **10** may be integrally formed by the element **22** and a body **32** of non-active material, so as to present a composite structure. For example, the element **22** may define a longitudinal section (e.g., the distal half of the interface **10**), or longitudinal/lateral strips. In another alternative, the element **22** may be embedded within a conformal non-active body **32**.

[0079] In the embodiment shown in FIG. **2**B, the body **32** defines a bulbous distal section, and the element **22** presents a strip of active material housed therein. The material, in this configuration, may be a suitable SMP or EAP. When activated, the element **22** is caused to lengthen or straighten (where the element **22** is in a bent configuration in the deactivated state as shown in planar view of FIG. **2**B), so as to exert an outward force upon the conformal body **32**. As a result, an originally circular lateral cross-section will be caused to change to an ellipsoidal cross-section across the distal section. More preferably, the element **22** in this configuration further includes distal engaging pads **33** to better distribute the modifying force.

[0080] In another embodiment, the interface **10** may define an exterior surface and an interior space configured to retain the element **22** (FIG. **2**C); the element **22** is inserted within the space and configured, relative thereto, so as to exert a modifying force upon the non-active material when activated