these preferred embodiments, but rather to enable any person skilled in the art to make and use this invention.

[0028] As shown in FIGS. **1** and **2**, the user interface system **100** of the preferred embodiment includes: a layer **110** defining a surface **115**, a substrate **120** supporting the layer **110** and at least partially defining a cavity **125**, a displacement device **130** coupled to the cavity **125** and adapted to expand the cavity **125** thereby deforming a particular region of the surface **115**, a touch sensor **140** coupled to the substrate **120** and adapted to sense a user touch proximate the particular region of the surface **115**, and a display **150** coupled to the substrate **120** and adapted to output images to the user.

[0029] The user interface system **100** of the preferred embodiments has been specifically designed to be incorporated into an electronic device, such as the display of an automotive console, a desktop computer, a laptop computer, a tablet computer, a television, a radio, a desk phone, a mobile phone, a PDA, a personal navigation device, a personal media player, a camera, or a watch. The user interface system may, however, be incorporated in any suitable device that interfaces with a user in both a visual and tactile manner.

1. The Layer and Substrate

[0030] As shown in FIG. **2**, the layer **110** of the preferred embodiment functions to provide the surface **115** that interfaces with a user in a tactile manner. The surface **115** is preferably continuous, such that when swiping a finger across the surface **115** a user would not feel any interruptions or seams. The surface **115** is also preferably planar. The surface **115** is preferably arranged in a flat plane, but may alternatively be arranged in a curved plane. The layer **110** also functions to deform upon an expansion of the cavity **125**, and to preferably "relaxes" or "un-deforms" back to a normal planar state upon retraction of the cavity **125**. The layer no is preferably elastic. In one version, the layer **110** is relatively more elastic in specific areas and relatively less elastic in other areas and is deformed in the relatively more elastic areas. In another version, the layer **110** is generally uniformly elastic. In yet another version, the layer **110** includes or is made of a smart material, such as Nickel Titanium (commonly referred to as "Nitinol"), that has a selective and/or variable elasticity. The layer **110** is preferably optically transparent, but may alternatively be translucent or opaque. In addition to the transparency, the layer no preferably has the following properties: a high transmission, a low haze, a wide viewing angle, a minimal amount of back reflectance upon the display **150** (if the display **150** is coupled with the user interface), scratch resistant, chemical resistant, stain resistant, and relatively smooth (not tacky) to the touch. The layer **110** is preferably made from a suitable elastic material, including polymers and silicon-based elastomers such as poly-dimethylsiloxane (PDMS) or RTV Silicon (e.g., RTV Silicon **615**). The layer **110** may, however, be made of any suitable material that provides the surface **115** and that deforms. In one version, the layer **110** is a single homogeneous layer less than 1 mm thick (preferably 50 to 200 microns). In another version, the layer **110** may be constructed using multiple layers or coatings from the same material or from different suitable materials.

[0031] The substrate **120** of the preferred embodiments functions to support the layer **110** and to at least partially define the cavity **125**. In one version, as shown in FIGS. **3***a* and **3***b*, the layer **110** is directly attached to the substrate **120** using an adhesive, ultra-sonic bonding, oxygen plasma surface treatment, or any other suitable techniques known to one skilled in the art. The substrate **120** and the layer **110**, in this version, cooperately define the cavity **125** (with the substrate **120** defining a "container" and the layer **110** defining a "membrane" over the "container"). In another version, as shown in FIGS. **4***a* and **4***b*, the layer **110** is indirectly attached to the substrate **120** with another element, such as the touch sensor **140** and/or the display **150** located between the layer no and the substrate **120**. The substrate **120** and the intervening element define the cavity **125** in this version. In yet another version, as shown in FIGS. **5***a* and **5***b*, the layer **110** and the substrate **120** are formed as a singular structure, which fully defines the cavity **125**. In yet one more version, as shown in FIGS. **6***a* and **6***b*, the substrate **120** may include a lattice-like support member **160** under the particular region of the surface **115**. When the cavity **125** is expanded and the deformation is present in the surface **115**, the support member **160** functions to prevent a user from "pressing too far" into the deformation below the plane of the surface **115**. When the cavity **125** is not expanded and the deformation is not present in the surface **115**, the support member **160** functions to reduce (or potentially eliminate) the user from feeling "divots" in the surface **115** when swiping a finger across the surface **115**. As shown in FIG. **6***c*, the support member **160** preferably includes holes or channels that allow for the expansion of the cavity **125** and the deformation of the surface **115**. The support member **160** is preferably integrally formed with the substrate **120**, but may alternatively be formed with the layer no or may be separately formed and later attached to the substrate **120**. Finally, as shown in FIG. **6***d*, the support member **160** may alternatively partially define the cavity **125**. The substrate **120** is preferably rigid, but may alternatively be flexible in one or more directions. The substrate **120**—if located above the display **150**—is preferably optically transparent, but may—if located below the display **150** or if bundled without a display **150**—be translucent or opaque. The substrate **120** is preferably made from a material including polymers or glass, for example, elastomers, silicon-based organic polymers such as poly-dimethylsiloxane (PDMS), thermoset plastics such as polymethyl methacrylate (PMMA), and photocurable solvent resistant elastomers such as perfluropolyethers. The substrate **120** may, however, be made of any suitable material that supports the layer **110** and at least partially defines the cavity **125**. In the preferred version, the substrate **120** is a single homogenous layer approximately 1 mm to 0.1 mm thick and can be manufactured using well-known techniques for microfluid arrays to create one or more cavities and/or micro channels. In alternative versions, the substrate **120** may be constructed using multiple layers from the same material or from different suitable materials.

[0032] As shown in FIGS. **3***a* and **3***b*, the cavity **125** of the preferred embodiment functions to hold a fluid and to have at least two volumetric settings: a retracted volume setting (shown in FIG. **3***a*) and an extended volume setting (shown in FIG. **3***b*). The fluid is preferably a liquid (such as water, glycerin, or ethylene glycol), but may alternatively be a gas (such as air, nitrogen, or argon) or any other substance (such as a gel or aerogel) that expands the cavity **125** and deforms the surface **115**. In the extended volume setting, the cavity **125** extends above the plane of the surface **115**, thereby deforming a particular region of the surface **115**. As explained above, the cavity **125** is preferably defined by the substrate **120** and the layer **110** (or an intervening element), or by the substrate **120** and layer no as a singular structure. In one