to 50%, which is a very characteristic feature compared to a piezoelectric element which exhibits a strain only as high as about 3%. Therefore, it is advantageous in that the EAP can be almost completely controlled by a suitable electric system.

[0042] The EAP has various advantages, such as small size, easy controllability, low power consumption, high response speed, or low potential cost. Due to such advantages, EAPs are currently being actively researched and developed in a wide variety of applications, such as artificial muscles, or the like.

[0043] Since the EAP outputs an electric signal corresponding to an external physical strain applied, if any, it can be used as sensor as well. Since materials of EAP typically generate a potential difference that can be electrically measured, the EAP can be used as a sensor of force, location, speed, accelerated speed, pressure, and so on. In addition, since the EAP has a two way memory, it can also be used as a sensor or an actuator.

[0044] Known examples of the EAP include gel, ionic polymer metal composite (IPM), electro-strictive polymer, and the like. Mechanism of most of EAP materials is based on ions moving inside and outside a polymeric network. Among the above stated EAPs, the electro-strictive polymer is known as the most practical polymer from the commercial point of view.

[0045] The electro-strictive polymer can be divided into two types: a dielectric type; and a shape-transition type. The dielectric type polymer is generally disposed such that a conductive electrode and a compliant electrode are sandwiched with the dielectric type polymer interposed therebetween. Under a high electric field, e.g., several hundreds to several thousands of volts, an attractive force associated with the electrodes presses dielectric materials, resulting in a large amount of deformation, i.e., approximately 50%.

[0046] FIGS. **3**A and **3**B illustrate the characteristics of an electro-active polymer (EAP) and particularly a dielectric polymer. In the description hereinbelow, a dielectric polymer is used as the electro-active polymer, but the present invention is not restricted thereto.

[0047] Referring to FIG. **3**A, two electrodes **32***a* and **32***b* respectively contact two sides of an electro-active polymer **31** having a predetermined thickness. Each of the two electrodes **32***a* and **32***b* is made of a thin film of a conductive polymer and has flexibility so that it is transformed following the transformation of the electro-active polymer **31**.

[0048] When the power of a power supply **30** is not supplied to the electrodes **32***a* and **32***b,* the electro-active polymer **31** is in an initial state as illustrated in FIG. **3**A. When the power of the power supply **30** is supplied to the electrodes **32***a* and **32***b,* the electro-active polymer **31** is transformed such that it becomes thinner and expands as illustrated in FIG. **3**B. Here, the electrodes **32***a* and **32***b* having flexibility are transformed following the transformation of the electro-active polymer **31**.

[0049] The present invention provides a haptic button having various functions using an electro-active polymer. In detail, a haptic button according to a first exemplary embodiment of the present invention provides a variable sense of touch to a user. Here, a plurality of haptic buttons having different stiffnesses may provide different operation feelings to a user or a single haptic button may have different stiffnesses according to circumstances. For example, stiffness of a Run button used in a car racing game may be increased when a user drives a car up a hill and decreased when the user drives the car down the hill so that the user can have the sense of touch similar to a real sensation.

[0050] A haptic button according to a second exemplary embodiment of the present invention provides different textures according to circumstances. Here, both of the stiffness and the texture of the haptic button may be changed.

[0051] A haptic button according to a third exemplary embodiment of the present invention allows a user to identify a button that the user touches at a current time without visually identifying it.

[0052] The basic concepts of the above-described three types of haptic buttons according to exemplary embodiments of the present invention will be described with reference to FIGS. **4**A through **6**B.

[0053] FIGS. **4**A and **4**B illustrate the basic concept of a haptic button according to a first exemplary embodiment of the present invention, in which FIG. **4**A illustrates a state of a haptic button **100** according to the first embodiment of the present invention before application of a voltage and FIG. **4**B illustrates a state of the haptic button **100** after the application of the voltage.

[0054] Referring to FIG. **4**A, two sides of the electro-active polymer **31** contact the two electrodes **32***a* and **32***b,* respectively. In other words, the two electrodes **32***a* and **32***b* and the electro-active polymer **31** form a sandwich structure. Two ends of the electro-active polymer **31** are fixed to a fixing portion **33** not to have displacement.

[0055] In this situation, when a voltage is applied to the two electrodes **32***a* and **32***b,* the electro-active polymer **31** is transformed as illustrated in FIG. **4**B. When the voltage is applied to the two electrodes **32***a* and **32***b,* the electro-active polymer **31** is expanded in a widthwise direction. Here, since the both ends of the electro-active polymer **31** are fixed to the fixing portion **33** and restricted in motion, the electro-active polymer **31** naturally protrudes upward or downward. If another element exists below the electro-active polymer **31** and restricts the downward protrusion of the electro-active polymer **31**, the electro-active polymer **31** will protrude upward.

[0056] In a case where the electro-active polymer **31** is designed to protrude upward, when a user presses the haptic button **100**, stiffness of the haptic button **100** may be controlled according to a voltage application state.

[0057] FIGS. **5**A and **5**B illustrate the basic concept of a haptic button according to a second exemplary embodiment of the present invention, in which FIG. **5**A illustrates a state of a haptic button **110** according to the first exemplary embodiment of the present invention before application of a voltage and FIG. **5**B illustrates a state of the haptic button **110** after the application of the voltage.

[0058] Referring to FIG. **5**A, the electro-active polymer **31** includes a plurality of notches **34** in a side contacting the upper electrode **32***a.* While a voltage is not applied to the two electrodes **32***a* and **32***b,* the notches **34** are closed. Accordingly, a user does not feel a special texture even though contacting the haptic button **110**.

[0059] However, when a voltage is applied to the two electrodes **32***a* and **32***b,* the electro-active polymer **31** protrudes upward and thus the notches **34** open, as illustrated in FIG. **5**B. At this time, if the user contacts the haptic button **110**, he/she will feel a rough texture. Even though the user does not directly contact the notches **34**, the user can feel the