the second electrode. The transducers may further include one or more conductive vias extending through the transducer at a location which includes the first electrode and a second conductive via extending through the transducer at a location which includes the second electrode. The present invention provides a variety of methods for forming the vias within the electroactive transducer, which methods may include forming via holes within the transducer and filling them with a conductive material or, alternatively, driving a conductive contact into the transducer material.

[0013] The electrode layers of the subject transducers may have any suitable trace pattern for the thickness mode application at hand. The patterns are typically symmetrical, but may be asymmetrical, where the opposing traces appose each other from opposite sides of the dielectric film, wherein the areas of electrode apposition are active and the remaining areas are inactive, wherein activation of the active areas increases a thickness dimension of the inactive areas. In certain embodiments, the respective trace patterns comprises a plurality of substantially parallel, spaced apart traces which may in turn form a concentric pattern, extend substantially straight or selectively bend or curve to provide a novelty shape.

[0014] The transducers may be fabricated from a continuous strip of electroactive polymer film where individual transducers are formed by singulating them from the strip. The electrode patterns may be formed continuously along the strip or may be discrete and repeating along the strip. The transducer strip may be shaped to frame an open space, which is particularly suitable for constructing gasket-type actuators.

[0015] These and other features, objects and advantages of the invention will become apparent to those persons skilled in the art upon reading the details of the invention as more fully described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The invention is best understood from the following detailed description when read in conjunction with the accompanying schematic drawings. To facilitate understanding, the same reference numerals have been used (where practical) to designate similar elements that are common to the drawings. Included in the drawings are the following:

[0017] FIGS. **1**A and **1**B schematically illustrate a surface deformation EAP transducer employed as an actuator which utilizes polymer surface features to provide work output when the transducer is activated;

[0018] FIGS. **2**A and **2**B are cross-sectional views of exemplary constructs of an actuator of the present invention;

[0019] FIGS. **3**A-**3**D illustrate various steps of a process for making electrical connections within the subject transducers for coupling to a printed circuit board (PCB) or flex connector;

[0020] FIGS. **4**A-**4**D illustrate various steps of a process for making electrical connections within the subject transducers for coupling to an electrical wire;

[0021] FIG. **5** is a cross-sectional view of a subject transducer having a piercing type of electrical contact;

[0022] FIGS. **6**A and **6**B are top views of a thickness mode transducer and electrode pattern, respectively, for application in a button-type actuator;

[0023] FIG. **7** illustrates a top cutaway view of a keypad employing an array of button-type actuators of FIGS. **6**A and **6**B;

[0024] FIG. **8** illustrates a top view of a thickness mode transducer for use in a novelty actuator in the form of a human hand;

[0025] FIG. **9** illustrates a top view of thickness mode transducer in a continuous strip configuration;

[0026] FIG. **10** illustrates a top view of a thickness mode transducer for application in a gasket-type actuator;

[0027] FIGS. **11**A-**11**D are cross-sectional views of touch screens employing various type gasket-type actuators;

[0028] FIGS. **12**A-**12**C are cross-sectional views of passive and active states, respectively, of a poppet valve mechanism employing the thickness mode actuators of the present invention;

[0029] FIGS. **13**A and **13**B are cross-sectional views of passive and active states, respectively, of a diaphragm-type fluid pump employing a thickness mode actuator of the present invention,

[0030] FIGS. **14**A and **14**B are cross-sectional views of another diaphragm-type pump employing thickness mode actuators of the present invention with the pump undergoing exhaust and compression strokes, respectively;

[0031] FIGS. **15**A and **15**B are cross-sectional views of peristaltic pump embodiments employing thickness mode actuators of the present invention;

[0032] FIGS. **16**A and **16**B are cross-sectional views of a linear brake mechanism employing the thickness mode actuators of the present invention in passive and active modes, respectively;

[0033] FIGS. **17**A and **17**B are cross-sectional views of a rotary brake or clutch mechanism employing the thickness mode actuators of the present invention in passive and active modes, respectively; and

[0034] FIGS. **18**A and **18**B are cross-sectional views of another embodiment of a thickness mode transducer of the present invention in which the relative positions of the active and passive areas of the transducer are inversed from the above embodiments.

[0035] Variations of the invention from what is shown in the figures are contemplated.

DETAILED DESCRIPTION OF THE INVENTION

[0036] The devices, systems and methods of the present invention are now described in detail with reference to the accompanying figures.

[0037] Referring to FIGS. **1**A and **1**B, a schematic representation is provided of a surface deformation EAP actuator **10** for converting electrical energy to mechanical energy in accordance with one embodiment of the invention. Actuator **10** includes EAP transducer **12** having a thin elastomeric dielectric polymer layer **14** and top and bottom electrodes **16**a, **16**b attached to the dielectric **14** on portions of its top and bottom surfaces, respectively. The portion of transducer **12** comprising the dielectric and at least two electrodes is referred to herein as an active area. Any of the transducers of the present invention may have one or more active areas.

[0038] When a voltage difference is applied across the oppositely-charged electrodes **16***a*, **16***b*, the opposed electrodes attract each other thereby compressing the portion of the dielectric polymer layer **14** therebetween. As the electrodes **16***a*, **16***b* are pulled closer together (along the z-axis), the portion of the dielectric layer **14** between them becomes thinner as it expands in the planar directions (along the x- and y-axes). For incompressible polymers, i.e., those having a substantially constant volume under stress, or for otherwise