compressible polymers held in a frame or the like, this action causes the compliant dielectric material outside the active area (i.e., the area covered by the electrodes), particularly perimetrically about, i.e., immediately around, the edges of the active area, to be displaced or bulge out-of-plane in the thickness direction (orthogonal to the plane defined by the transducer film). This bulging produces dielectric surface features **24***a-d.* While out-of-plane surface features **24** are shown relatively local to the active area, the out-of-plane is not always localized as shown. In some cases, if the polymer is pre-strained, then the surface features **24***a-b* are distributed over a surface area of the inactive portion of the dielectric material.

[0039] In order to amplify the vertical profile and/or visibility of surface features of the subject transducers, an optional passive layer may be added to one or both sides of the transducer film structure where the passive layer covers all or a portion of the EAP film surface area. In the actuator embodiment of FIGS. **1**A and **1**B, top and bottom passive layers **18***a*, **18***b* are attached to the top and bottom sides, respectively, of the EAP film **12**. Activation of the actuator and the resulting surface features **17***a-d* of dielectric layer **12** are amplified by the added thickness of passive layers **18***a*, **18***b*, as denoted by reference numbers **26***a-d* in FIG. **1**B.

[0040] In addition to the elevated polymer/passive layer surface features **26***a-d*, the EAP film **12** may be configured such that the one or both electrodes **16***a*, **16***b* are depressed below the thickness of the dielectric layer. As such, the depressed electrode or portion thereof provides an electrode surface feature upon actuation of the EAP film **12** and the resulting deflection of dielectric material **14**. Electrodes **16***a*, **16***c* may be patterned or designed to produce customized transducer film surface features which may comprise polymer surface features, electrode surface features and/or passive layer surface features.

[0041] In the actuator embodiment **10** of FIGS. **1**A and **1**B, one or more structures **20***a*, **20***b* are provided to facilitate coupling the work between the compliant passive slab and a rigid mechanical structure and directing the work output of the actuator. Here, top structure **20***a* (which may be in the form of a platform, bar, lever, rod, etc.) acts as an output member while bottom structure **20***b* serves to couple actuator **10** to a fixed or rigid stricture **22**, such as ground. These output structures need not be discrete components but, rather, may be integrated or monolithic with the structure which the actuator is intended to drive. Structures **20***a*, **20***b* also serve to define the perimeter or shape of the surface features **26***a-d* formed by the passive layers **18***a*, **18***b*. In the illustrated embodiment, while the collective actuator stack produces an increase in thickness of the actuator's inactive portions, as shown in FIG. **1**B, the net chance in height Δh undergone by the actuator upon actuation is negative.

[0042] The EAP transducers of the present invention may have any suitable construct to provide the desired thickness mode actuation. For example, more than one EAP film layer may be used to fabricate the transducers for use in more complex applications, such as keyboard keys with integrated sensing capabilities where an additional EAP film layer may be employed as a capacitive sensor.

[0043] FIG. **2**A illustrates such an actuator **30** employing a stacked transducer **32** having a double EAP film layer **34** in accordance with the present invention. The double layer includes two dielectric elastomer films with tile top film **34***a* sandwiched between top and bottom electrodes **34***b*, **34***c*, respectively, and the bottom film **36***a* sandwiched between top and bottom electrodes **36***b*, **36***c*, respectively. Pairs of conductive traces or layers (commonly referred to as "bus bars") are provided to couple the electrodes to the high voltage and ground sides of a source of power (the latter not shown). The bus bars are positioned on the "inactive" portions of the respective EAP films (i.e., the portions in which the top and bottom electrodes do not overlap). Top and bottom bus bars **42***a*, **42***b* are positioned on the top and bottom sides, respectively, of dielectric layer **34***a*, and top and bottom bus bars **44***a*, **44***b* positioned on the top and bottom sides, respectively, of dielectric layer **36***a*. The top electrode **34***b* of dielectric **34***a* and the bottom electrode **36***c* of dielectric **36***a*, i.e., the two outwardly facing electrodes, are commonly polarized by way of the mutual coupling of bus bars **42***a* and **44***a* through conductive elastomer via **68***a* (shown in FIG. **2**B), the formation of which is described in greater detail below with respect to FIGS. **3**A-**3**D. The bottom electrode **34***c* of dielectric **34***a* and the top electrode **36***b* of dielectric **36***a*, i.e., the two inwardly facing electrodes, are also commonly polarized by way of the mutual coupling of bus bars **42***b* and **44***b* through conductive elastomer via **68***b* (shown in FIG. **2**B). Potting material **66***a*, **66***b* is used to seal via **68***a*, **68***b*. When operating the actuator, the opposing electrodes of each electrode pair are drawn together when a voltage is applied. For safety purposes, the ground electrodes may be placed on the outside of the stack so as to ground any piercing object before it reaches the high voltage electrodes, thus eliminating a shock hazard. The two EAP film layers may be adhered together by film-to-film adhesive **40***b*. The adhesive layer may optionally include a passive or slab layer to enhance performance. A top passive layer or slab **50***a* and a bottom passive layer **52***b* are adhered to the transducer structure by adhesive layer **40***a* and by adhesive layer **40***c*. Output bars **46***a*, **46***b* may be coupled to top and bottom passive layers, respectively, by adhesive layers **48***a*, **48***b*, respectfully.

[0044] The actuators of the present invention may employ any suitable number of transducer layers, where the number of layers may be even or odd. In the latter construct, one or more common ground electrode and bus bar may be used. Additionally, where safety is less of an issue, the high voltage electrodes may be positioned on the outside of the transducer stack to better accommodate a particular application.

[0045] To be operational, actuator **30** must be electrically coupled to a source of power and control electronics (neither are shown). This may be accomplished by way of electrical tracing or wires on the actuator or on a PCB or a flex connector **62** which couples the high voltage and ground vias **68***a*, **68***b* to a power supply or an intermediate connection. Actuator **30** may be packaged in a protective barrier material to seal it from humidity and environmental contaminants. Here, the protective barrier includes top and bottom covers **60**, **64** which are preferably sealed about PCB/flex connector **62** to protect the actuator from external forces and strains and/or environmental exposure. In some embodiments, the protective barrier maybe impermeable to provide a hermetic seal. The covers may have a somewhat rigid form to shield actuator **30** against physical damage or may be compliant to allow room for actuation displacement of the actuator **30**. In one specific embodiment, the top cover **60** is made of formed foil and the bottom cover **64** is made of a compliant foil, or vice versa, with the two covers then heat-sealed to board/connector **62**. Many other packaging materials such as metalized polymer films, PVDC, Aclar, styrenic or olefinic copolymers,