[0016] As is illustrated in FIG. 2, a bimorph actuator **300**, comprised of a passive material or substrate or beam **301**, fixed end **302**, a top layer of active material **305** and a bottom layer of active material **355**. In one embodiment the top active material **305** and the bottom active material **355** are both comprised of piezoelectric materials. The top active material **305** is polarized **320** along the plane of the material, parallel to the beam **301** of the actuator. This top active material **305** is subjected to a positive electric field **310**.

[0017] In an alternate embodiment, the top active material **305** and bottom active material **355** are not separated by a passive material but are connected directly. In such an embodiment, the connection may include the presence of an adhesive, such as an epoxy, between the top active material **305** and the bottom active material **355**.

[0018] The bottom active material **355** is polarized **350** through the thickness of the active material **355**, perpendicular to the beam **301** of the actuator. This bottom active material is also subjected to a positive electric field **340**. Although both the top active material **305** and the bottom active material **355** are subjected to a positive electric field in the direction of polarization, the actuator bends due to piezoelectric coefficients which are opposite in signs. Depending on the desired results the electric fields that are applied to the top and bottom active materials vary, and they may be the same or different strength electric fields.

[0019] In the embodiment wherein the top active material **305** and the bottom active material **355** are piezoelectric materials, the top piezoelectric material is polarized along the plane of the piezoelectric wafer such that the d33 piezoelectric coefficient is exploited (d33=374 pm/V for PZT 5A (available from Morgan Electro Ceramics, Bedford, Ohio)). The bottom piezoelectric material is polarized through the thickness such that the d31 piezoelectric coefficient is exploited (d31=−171 pm/V). Again, even though there is a positive electric field on both sides of the actuator, the actuator bends because the d33 and d31 coefficients are opposite in sign. Thus, the top expands and the bottom contracts from the piezo coefficient orientation, rather than the sign of the electric field.

[0020] As both active materials are subjected to positive electric fields, they do not exhibit the same problems as exhibited when an active material, particularly a piezoelectric material, is subjected to a negative electric field and an elevated temperature. In those cases, depolarization is seen at temperatures as low as about 50° C. In the present embodiments, there are no electric fields applied against the direction of polarization, therefore the active materials, such as piezoelectric materials, will retain their polarization at levels of at least about 50% of Curie temperature. For one common piezoelectric material PZT 5A, the piezoelectric properties are retained up to at least about 150° C., one half of Curie temperature.

[0021] The piezoelectric material can be comprised of known man made or industrial materials. For instance monolithic ceramic can be used, or a macro fiber composite (MFC) is an alternative. The MFCs have the added advantage that they result in much larger forces, and therefore greater movement is exhibited by the actuator. An MFC may be comprised of a sheet of aligned rectangular piezoceramic fibers, layered on each side with structural epoxy, which is then covered by polyimide film. The sheets of aligned rectangular piezoceramic fibers provide the added advantage of improved damage tolerance and flexibility relative to monolithic ceramics. The structural epoxy inhibits crack propagation in the ceramic and bonds the actuator components together. The polyimide film, which is the top and bottom layers of the actuator, may be comprised of an interdigitated electrode pattern on the film, and permit in-plane poling and actuation of the piezoceramic.

[0022] The fabrication process then is comprised of the creation of the piezo fibers, which are then connected or laminated to the pattern electrodes on dialectic film. The created piezoelectric components are then bonded to a substrate. MFCs can be made to size requirements, such as about 1.3 cm^2, so as to meet the limited spaces available for switches and relays which may, for example, be inserted in control boards of electronic devices.

[0023] An additional embodiment of the invention addresses the issue of providing power to the bimorph actuator. Due to certain desired characteristics, such as limited space, a small power source is a preferred source to operate the bimorph actuator. One embodiment of such a power source is a 3V battery. However, the power desired or required to operate the active material is 1500V when MFC is used as the active material. Therefore, a means was found in order to convert a 3V battery power source to 1500V without electrically stressing the components that go into the circuit. One means of accomplishing this was to create two halves or channels, each of which would provide half of the voltage required, connected such that the ground point was at the mid voltage point, and when combined provide 100%. In order to increase the power, a Flyback type DC to DC converter was used. In one channel, the conversion resulted in +750 volts, while in the second or alternate channel, the conversion resulted in −750 volts. The voltages are additive, and result in the desired 1500 vs for operating the actuator.

[0024] While typical embodiments have been set forth for the purpose of illustration, the foregoing descriptions should not be deemed to be a limitation on the scope herein. It is apparent that numerous other forms and modifications of this invention will occur to one skilled in the art without departing from the spirit and scope herein. The appended claims and these embodiments should be construed to cover all such obvious forms and modifications that are within the true spirit and scope of the present invention.

[0025] The following example is set forth to provide those of ordinary skill in the art with a detailed description of how the compositions and objects claimed herein are evaluated, and are not intended to limit the scope of what the inventors regard as their invention.

EXAMPLE

[0026] A bimorph actuator comprised of PZT 5A ceramic piezoelectric material in the form of an MFC as the top and bottom active materials, toughened epoxy and Invar as the substrate was fabricated. The bimorph actuator was clamped at one end to a stationary object. An environmental chamber was used to create a uniform zone of air around the bimorph actuator at elevated temperature. The stroke of the bimorph actuator was measured with a laser measurement system through a small hole in the environmental chamber. The voltage was set to a typical operating voltage (1500 v for the top active material and 300 v for the bottom active material. The temperature was raised from 20° C. to 80° C. in ten degree increments with stroke measurements performed at each interval. The results in the following graph shows deflection within specification due to the symmetric structure.