additionally comprises an open loop control source in electrical communication with the at least two electrodes and designed or configured to set or change an electrical state that results in a desired damping for the device. The system also comprises dissipative electronics in electrical communication with the at least two electrodes and designed or configured to dump electrical energy in response to a change in the electrical state.

In another aspect, the present invention relates to a system for providing damping using an electroactive polymer transducer. The system comprises a device including a mechanical interface capable of displacement. The device also comprises a transducer comprising at least two electrodes, and an electroactive polymer in electrical communication with the at least two electrodes and coupled to the mechanical interface. The polymer is arranged in a manner that allows deflection of the polymer corresponding to displacement of the mechanical interface. The system further comprises control electronics in electrical communication with the at least two electrodes and designed or configured to set or change an electrical state that results in a desired damping for the device. The system also comprises dissipative electronics in electrical communication with the at least two electrodes and designed or configured to dump electrical energy in response to a change in the electrical state. The system additionally comprises a sensor configured to detect a parameter related to the desired damping and provide feedback to the control electronics.

In yet another aspect, the present invention relates to a method for providing a desired stiffness using an electroactive polymer transducer. The transducer comprises at least two electrodes and an electroactive polymer in electrical communication with the at least two electrodes. The method comprises applying a substantially constant voltage to the at least two electrodes using control electronics in electrical communication with the at least two electrodes.

In still another aspect, the present invention relates to a method for providing a desired stiffness using an electroactive polymer transducer. The transducer comprises at least two electrodes an electroactive polymer in electrical communication with the at least two electrodes. The method comprises applying a substantially constant charge to the transducer using control electronics in electrical communication with the at least two electrodes.

In another aspect, the present invention relates to a method for providing a desired stiffness using an electroactive polymer transducer. The transducer comprises at least two electrodes and an electroactive polymer in electrical communication with the at least two electrodes. The method comprises applying an electrical state to the transducer, using control electronics in electrical communication with the at least two electrodes, that places the polymer in a stiffness regime corresponding to the desired stiffness.

In still another aspect, the present invention relates to a system for providing a desired stiffness for a portion of footwear. The system comprises footwear designed or configured for human usage. The footwear includes a portion capable of displacement. The footwear also includes a transducer comprising at least two electrodes, and an electroactive polymer in electrical communication with the at least two electrodes and coupled to the portion. The polymer is arranged in a manner that allows deflection of the polymer corresponding to displacement of the portion. The system also comprises control electronics in electrical communication with the at least two electrodes and designed or configured to set or change the electrical state of the transducer in order to cause a corresponding setting or change in the stiffness of the device.

In yet another aspect, the present invention relates to a method for resisting motion of a mechanical interface included in a device. The device includes an electroactive polymer transducer comprising at least two electrodes an electroactive polymer in electrical communication with the at least two electrodes and coupled to the mechanical interface. The method comprises actuating the polymer out of phase from motion of the mechanical interface that causes the polymer to contract. The method also comprises absorbing electrical energy in generator mode out of phase from motion of the mechanical interface that causes the polymer to expand.

These and other features and advantages of the present invention will be described in the following description of the invention and associated figures.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

FIG. **1**A illustrates a top perspective view of a transducer portion in accordance with one embodiment of the present invention.

FIG. **1**B illustrates a top perspective view of the transducer portion of FIG. **1**A including deflection.

FIG. **1**C illustrates a monolithic transducer **25** comprising a plurality of active areas in accordance with one embodiment of the present invention.

FIG. **2**A illustrates an electrical schematic of an open loop variable stiffness/damping system in accordance with one embodiment of the present invention.

FIG. **2**B illustrates exemplary relationships between force and deflection for the transducer included in the system of FIG. **2**A, according to constant charge and constant voltage states applied to electrodes included in the transducer in accordance with specific techniques of the present invention.

FIG. **3**A illustrates a high level schematic of a closed loop stiffness and damping system in accordance with one embodiment of the present invention.

FIG. **3**B illustrates a stiffness range for a transducer resulting from varying voltages actively provided by control electronics in accordance with one embodiment of the present invention.

FIG. **4**A illustrates a bending transducer for providing variable stiffness based on structural changes related to polymer deflection in accordance with one embodiment of the present invention.

FIG. **4**B illustrates the transducer of FIG. **4**A with a 90 degree bending angle.

FIG. **4**C illustrates a bow device suitable for providing variable stiffness in accordance with another embodiment of the present invention.

FIG. **4**D illustrates the bow device of FIG. **4**C after actuation.

FIG. **4**E shows an exemplary stiffness relationship for an electroactive polymer to facilitate illustration of stiffness regime control using an electroactive polymer transducer.

FIGS. **5**A and **5**B illustrate a linear motion device suitable for stiffness and damping control in a single direction, in accordance with one embodiment of the present invention.

FIG. **5**C illustrates cross-sectional side view of a multilayer device for providing stiffness and damping control in accordance with one embodiment of the present invention.