or electrical performance. Generally, electrodes suitable for use with the present invention may be of any shape and material provided that they are able to supply a suitable voltage to, or receive a suitable voltage from, an electroactive polymer. The voltage may be either constant or varying over time. In one embodiment, the electrodes adhere to a surface of the polymer. Electrodes adhering to the polymer may be compliant and conform to the changing shape of the polymer. The electrodes may be only applied to a portion of an electroactive polymer and define an active area according to their geometry. As will be described below, the electrodes may also be patterned to achieve a desired shape for a surface feature created by deflection of the polymer.

[**0062**] In one embodiment, electrodes **14** and **16** are compliant and conform to the shape of an electroactive polymer to which they are attached. Referring back to **FIGS. 1A and 1B**, the configuration of polymer **12** and electrodes **14** and **16** provides for increasing polymer **12** response with deflection. More specifically, as the transducer portion **10** deflects, compression of polymer **12** brings the opposite charges of electrodes **14** and **16** closer and the stretching of polymer **12** separates similar charges in each electrode. In one embodiment, one of the electrodes **14** and **16** is ground.

[**0063**] Various types of electrodes suitable for use with the present invention are described in commonly owned, copending U.S. patent application Ser. No. 09/619,848, which was previously incorporated by reference above. Electrodes described therein and suitable for use with the present invention include structured electrodes comprising metal traces and charge distribution layers, textured electrodes, conductive greases such as carbon greases or silver greases, colloidal suspensions, high aspect ratio conductive materials such as carbon fibrils and carbon nanotubes, and mixtures of ionically conductive materials.

[**0064**] The present invention may also employ metal and semi-flexible electrodes. In one embodiment, a rigid electrode comprises a metal disposed in a thick layer that is not capable of significant bending or planar stretching. In another embodiment, a semi-flexible electrode comprises a metal disposed in thin sheets such that the metal layer, like tin foil for example, is flexible out-of-plane but relatively rigid in plane. Thus, the polymer may deflect out-of-plane as described above but deflections in plane are limited to elastic strain of the metal sheet. Another flexible out-of-plane but relatively rigid in plane electrode may comprise a sheet of aluminized mylar. In another embodiment, the metal is disposed in thick sheets such that the metal layer is rigid and restrains the polymer from deflection on the attached surface.

[**0065**] Materials used for electrodes of the present invention may vary. Suitable materials used in an electrode may include graphite, carbon black, colloidal suspensions, thin metals including silver and gold, silver filled and carbon filled gels and polymers, gelatin, and ionically or electronically conductive polymers. In a specific embodiment, an electrode suitable for use with the present invention comprises 80 percent carbon grease and 20 percent carbon black in a silicone rubber binder such as Stockwell RTV60-CON as produced by Stockwell Rubber Co. Inc. of Philadelphia, Pa. The carbon grease is of the type such as NyoGel 756G as provided by Nye Lubricant Inc. of Fairhaven, Mass. The conductive grease may also be mixed with an elastomer, such as silicon elastomer RTV 118 as produced by General Electric of Waterford, N.Y., to provide a gel-like conductive grease.

[**0066**] It is understood that certain electrode materials may work well with particular polymers and may not work as well for others. For most transducers, desirable properties for the compliant electrode may include one or more of the following: low modulus of elasticity, low mechanical damping, low surface resistivity, uniform resistivity, chemical and environmental stability, chemical compatibility with the electroactive polymer, good adherence to the electroactive polymer, and the ability to form smooth surfaces. In some cases, a transducer of the present invention may implement two different types of electrodes, e.g., a different electrode type for each active area or different electrode types on opposing sides of a polymer.

[**0067**] Electronic drivers are typically connected to the electrodes. The voltage provided to an electroactive polymer will depend upon specifics of an application. In one embodiment, a transducer of the present invention is driven electrically by modulating an applied voltage about a DC bias voltage. Modulation about a bias voltage allows for improved sensitivity and linearity of the transducer to the applied voltage. For example, a transducer used in an audio application may be driven by a signal of up to 200 to 1000 volts peak to peak on top of a bias voltage ranging from about 750 to 2000 volts DC.

[**0068**] In accordance with the present invention, the term "monolithic" is used herein to refer to electroactive polymers, transducers, and devices comprising a plurality of active areas on a single polymer. **FIG. 1F** illustrates a monolithic transducer **150** comprising a plurality of active areas in accordance with one embodiment of the present invention. The monolithic transducer **150** converts between electrical energy and mechanical energy. The monolithic transducer **150** comprises an electroactive polymer **151** having two active areas **152***a* and **152***b*.

[**0069**] Active area **152***a* has top and bottom electrodes **154***a* and **154***b* that are attached to polymer **151** on its top and bottom surfaces **151***c* and **151***d*, respectively. The electrodes **154***a* and **154***b* provide a voltage difference across a portion **151***a* of polymer **151**. The portion **151***a* deflects with a change in electric field provided by the electrodes **154***a* and **154***b*. More specifically, portion **151***a* expands in the plane and thins vertically—or orthogonal to the plane—with a suitable voltage difference across a portion **151***a*. The portion **151***a* comprises the polymer **151** between the electrodes **154***a* and **154***b* and any other portions of the polymer **151** having sufficient stress induced by the electrostatic force to enable deflection and thinning upon application of voltages using the electrodes **154***a* and **154***b*.

[**0070**] Active area **152***b* has top and bottom electrodes **156***a* and **156***b* that are attached to the polymer **151** on its top and bottom surfaces **151***c* and **151***d*, respectively. The electrodes **156***a* and **156***b* provide a voltage difference across a portion **151***b* of polymer **151**. The portion **151***b* deflects with a change in electric field provided by the electrodes **156***a* and **156***b*. More specifically, portion **151***a* expands in the plane and thins vertically—or orthogonal to the plane—with a suitable voltage difference across a portion **151***a*. The portion **151***b* comprises polymer **151** between the electrodes **156***a* and **156***b* and any other portions of the polymer **151**