In one embodiment, surface deformation transducers and devices may be used for sound generation applications, such as speakers. Further description of sound generation using a an electroactive polymer is described in U.S. Pat. No. 6,343,129, which is incorporated herein in its entirety and for all the purposes.

In another embodiment, a surface deforming electroactive polymer transducer device may be actuated to increase or decrease the friction coefficient between an object and a surface. In one embodiment, the surface deforming transducer device may be mounted across the bottom of the object an actuated in a manner to provide a variable coefficient of friction across the bottom of the object. The variable coefficient of friction may be used to generate frictional steering. One application where friction control may be applied is on the bottom of skis or snowboards. The friction control may be used for aiding in the braking or turning of the skis or snowboard.

FIG. **5**B illustrates surface deforming electroactive polymer transducers **340** and **342** mounted to a surface of a wing **343** and a flap **345**, respectively, in accordance with a specific embodiment of the present invention. The actuation of transducers **340** and **342** changes a property of airflow over the wing **343** and flap **345**. For instance, active areas on transducer **340** may be actuated to increase or decrease lift and drag on the wing depending on the operating conditions of the wing, e.g., actuated to increase surface roughness and turbulence of airflow passing thereover. In other embodiments, the actuation of transducers **340** and **342** may be used to change the radar cross-sectional properties of the wing surface.

Other exemplary applications for surface deforming electroactive polymer transducers include 1) Braille devices, 2) touch sensitive devices, such as key boards or other interfaces, where the surface deforming transducers are actuated to provide tactile feedback, 3) massagers, 4) vibration devices, 5) pumps and 6) linear actuators. In the Braille device, the surface deforming transducers may be used to create a surface texture that is readable by touch as Braille. In another related application, surface deforming transducers may be used in a 3-D topography display where the surface texture is representative of surface topography of a geographic region.

In one specific embodiment, a transducer with a passive layer on each opposing surface is sandwiched between two rigid conductive layers, such as two metal layers, to generate a variable capacitance capacitor. By actuating the polymer and the passive layers to vary the distance between the two metal layers, the capacitance of the capacitor may be varied when the metal layers are charged.

Changing the texture of a surface is also desirable in military applications such as 'active' military camouflage materials that alter their reflectance.

In one embodiment, actuators and transducers of the present invention are employed for performing thermodynamic work on a fluid in a fluid system or controlling a fluid. Fluid systems are ubiquitous. The automotive industry, plumbing industry, chemical processing industry and aerospace industry are a few examples where fluid systems are widely used. In fluid systems, it is often desirable to control properties of a fluid flow in the fluid system to improve a performance or efficiency of the fluid system or to control the fluid in the fluid system in manner that allows the fluid system to operate for a specific purpose. One method of control of a fluid is through control of a fluid-surface interface. The present invention may then include devices and methods for controlling a fluid surface interface using one or more electroactive polymer actuator devices and surface interfaces. In a specific embodiment, surface deforming transducers are mounted to an inner surface of a fluid conduit. The surface deforming transducers may be actuated to generate wave patterns in the conduit. For instance, the wave patterns may be used to promote mixing. Alternatively, the surface deforming transducers may be actuated to reduce friction in the conduit.

In another specific application, a passive layer connects to a mechanical output or linkage so that thickness displacements generated by a polymer are transferred to the linkage. Deflection of the polymer then controls a state for the mechanical output, namely, the mechanical output has a first state before deflection and a second state after deflection. For example, a surface deforming transducer (or portion thereof) may be used to control a position of the mechanical output or an object that is connected to the mechanical linkage. Alternatively, a surface deforming transducer (or portion thereof) may be used to control a shape of the mechanical output. For example, the mechanical output may include a mirrored surface that is disposed on the passive layer and deflection of the polymer is used to change the shape or position of the mirror to vary light reflected by the mirror.

8. Conclusion

While this invention has been described in terms of several preferred embodiments, there are alterations, permutations, and equivalents that fall within the scope of this invention which have been omitted for brevity's sake. By way of example, although the present invention has been described in terms of several polymer materials and geometries, the present invention is not limited to these materials and geometries. It is therefore intended that the scope of the invention should be determined with reference to the appended claims.

What is claimed is:

1. A method of actuating an electroactive polymer transducer, the method comprising:

providing an actuation voltage between a first electrode disposed on a portion of a first surface of an electroactive polymer and a second electrode disposed on a portion of a second surface of the electroactive polymer;

in response to the actuation voltage, deflecting the electroactive polymer to include a polymer surface feature above an undeflected thickness for a surface region on the first surface of the polymer, wherein the polymer surface feature includes a portion of the electroactive polymer that is outside the portion of the first surface of the electroactive polymer that the first electrode is disposed on.

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