Claims

1. A device comprising:

a prestretched layer, the prestretched layer having a first surface and a second surface defining a variable thickness therebetween;

a first passive layer, the first passive layer defining an actuator surface and a third surface;

a first actuator electrode, the first actuator electrode being disposed between the first surface of the prestretched layer and the actuator surface of the first passive layer;

a second actuator electrode, the second actuator electrode being disposed on the second surface of the prestretched layer, the first actuator electrode and the second actuator electrode being characterized by an actuator electrode gap corresponding to the variable thickness of the prestretched layer, wherein each of the first actuator electrode and the second actuator electrode is formed of an ionic gel, and wherein the prestretched layer and the first passive layer are respective elastomer layers.

2. The device according to claim 1, comprising:

a first electroadhesion electrode; and

a second electroadhesion electrode, the first electroadhesion electrode and the second electroadhesion being disposed on the third surface of the first passive layer, wherein each of the first electroadhesion electrode and the second electroadhesion electrode is formed of an ionic gel.

3. The device according to claim 1 or 2, further comprising: a contact layer, wherein the first electroadhesion electrode and the second electroadhesion electrode are disposed between the contact layer and the first passive layer.

4. The device according to claim 3, further comprising a hydrophobic coating coated on the contact layer.

5. The device according to any one of claims 1 to 4, further comprising a second passive layer disposed on the second actuator electrode, wherein the second passive layer and the first passive layer are compositionally similar, and wherein the first passive layer is thicker than the second passive layer.

6. The device according to any one of claims 2 to 5, wherein each of the first electroadhesion electrode and the second electroadhesion electrode comprises respective first electrode fingers and second electrode fingers, and wherein the first electrode fingers and the second electrode fingers are interleaved with one another and define an electroadhesion electrode gap therebetween.

7. The device according to any one of claims 2 to 6, wherein the electroadhesion electrode gap is oriented orthogonally to the actuator electrode gap.

8. The device according to any one of claims 2 to 7, wherein the first actuator electrode, the prestretched layer, and the second actuator electrode are elongate along a longitudinal axis, and wherein the first electroadhesion electrode and the second electroadhesion electrode are coplanarly disposed on a third surface that is parallel to the longitudinal axis.

9. The device according to any one of claims 1 to 8, wherein the ionic gel includes mobile ions dissolved in a solvent swollen in one or more polymer matrix.

10. The device according to claim 9, wherein the one or more polymer matrix comprises any one or more selected from the group consisting of: neutral polymers and one or more polyions, and wherein the one or more polyions include any one or more selected from the group consisting of: positively charged polyions and negatively charged polyions.

11. The device according to claim 10 wherein the neutral polymers comprises any one or more selected from the group consisting of: polyacrylate, one or more derivatives of polyacrylate, polyethylene glycol, one or more derivatives of polyethylene glycol, polyvinyl alcohol, polyvinylpyrrolidone, polyhydroxyethyl methacrylate, and any copolymer with a plurality of cross-linkable groups.

12. The device according to any one of claims 1 to 9, where the ionic gel is a neutral polymer-based ionic gel comprising a crosslinked network of a neutral polymer, a solvent swollen in the crosslinked network, mobile cations dissolved in the solvent, and mobile anions dissolved in the solvent.

13. The device according to claim 10 wherein the one or more polyions comprises any one or more selected from the group consisting of: polyacrylic acid, poly(2-acrylamido-2-methylpropane sulfonic acid), poly(diallyl dimethylammonium chloride), and polystyrene sulfonate.

14. The device according to any one of claims 1 to 9, wherein the ionic gel is a polyion-based ionic gel comprising a polyion with a charged polyion backbone, a solvent swollen in a network of the polyion, and a solvent with mobile counterions dissolved in the solvent, and wherein the mobile counterions are mobile ions released from the polyion and oppositely charged from the charged polyion backbone.

15. The device according to any one of claims 1 to 14, wherein the ionic gel is characterized by an elastic modulus in a range from 1 kPa to 100 kPa.

16. The device according to any one of claims 1 to 15, wherein the prestretched layer is formed of an elastomer characterized by an elastic modulus in a range from 100 ka to 50 MPa.

17. The device according to any one of claims 1 to 15, wherein the first passive layer is formed of an elastomer characterized by an elastic modulus in a range from 100 ka to 50 MPa.

18. The device according to claim 16 or claim 17 , wherein the elastomer is any one or more selected from the group consisting of: polysiloxanes, polyurethanes, latex, acrylic elastomers, and styrene-butadiene elastomers.

19. The device according to claim 3, wherein the contact layer comprises an elastic material, the elastic material being any one selected from the group consisting of: polysiloxanes, polyurethanes, latex, acrylic elastomers, and styrene-butadiene elastomers.

20. A gripper suitable for use in handling an object, the gripper comprising:

a connector; and

two or more devices as recited in any one of claims 2 to 19, each of the two of more devices having a proximal end and a distal end, the proximal end being coupled to the connector, wherein the respective first electroadhesion electrode and the second electroadhesion electrode are positioned at the distal end.

21. The gripper according to claim 20, further comprising: a controller voltage supply to the gripper, the voltage supply being configured to provide a first voltage signal across the first actuator electrode and the second actuator electrode, wherein responsive to a first voltage difference across the first actuator electrode and the second actuator electrode, the two or more devices are operable to each bend relative to the longitudinal axis.

22. The gripper according to claim 20, further comprising: a voltage supply coupled to the gripper, the voltage supply being configured to provide: a second voltage drop across the first electroadhesion electrode and the second electroadhesion electrode, wherein responsive to a second voltage difference across the first electroadhesion electrode and the second electroadhesion electrode, electroadhesive forces are generated at respective distal end to provide a conformal electrostatic adhesion between the respective device and the object.

23. The gripper according to claim 20, further comprising: a controller coupled to the gripper, the controller being configured to determine a proximity or a contact between the respective device and the object responsive to sensing a change in a capacitance across the respective first electroadhesion electrode and the respective second electroadhesion electrode of the respective device.