CLAIMS

1. A piezoelectric device comprising:

a substrate; and

a layered stacked arrangement anchored to the substrate, the layered stacked arrangement comprising:

a piezoelectric layer;

a first electrode on a first side of the piezoelectric layer; and

a second electrode on a second side of the piezoelectric layer opposite the first side;

wherein the piezoelectric layer comprises a first region comprising one or more dipole domains of a first type;

wherein the piezoelectric layer comprises a second region comprising one or more dipole domains of a second type;

wherein the first electrode is at least partially in contact with the first region and at least partially in contact with the second region;

wherein the second electrode is at least partially in contact with the first region and at least partially in contact with the second region;

wherein the piezoelectric device is a sensor or an actuator; ~~and~~

~~wherein during operation, at least 50% of the first region is configured to have a positive curvature and at least 50% of the second region is configured to have a negative curvature~~wherein the piezoelectric device further comprises a gap material between the first region and the second region; and

wherein the gap material has a dielectric constant lower than a dielectric constant of a piezoelectric material of the piezoelectric layer.

2. The piezoelectric device according to claim 1,

wherein the one or more dipole domains of the first type are aligned in a first direction; and

wherein the one or more dipole domains of the second type are aligned in a second direction opposite the first direction.

3. The piezoelectric device according to claim 1,

wherein the one or more dipole domains of the first type or the one or more dipole domains of the second type are non-uniformly poled.

4. The piezoelectric device according to claim 1,

wherein the first electrode or the second electrode is an elastic layer.

5. The piezoelectric device according to claim 1,

wherein the layered stacked arrangement comprises a further layer such that the first electrode or the second electrode is between the piezoelectric layer and the further layer.

6. The piezoelectric device according to claim 5,

wherein the further layer is electrically conductive or electrically semi-conductive.

7. The piezoelectric device according to claim 5,

wherein the further layer is electrically insulating.

8. The piezoelectric device according to claim 5,

wherein the further layer is a further piezoelectric layer.

9. The piezoelectric device according to claim 1,

wherein the piezoelectric layer is polycrystalline.

~~10. The piezoelectric device according to claim 1, further comprising:~~

~~a gap material between the first region and the second region;~~

~~wherein the gap material has a dielectric constant lower than a dielectric constant of a piezoelectric material of the piezoelectric layer.~~

~~11.~~10. The piezoelectric device according to claim 1,

where the piezoelectric layer comprises a ferroelectric wurtzite-type material.

~~12.~~11. The piezoelectric device according to claim 1,

where the piezoelectric layer has a thickness of a value less than 5 μm.

~~13.~~12. The piezoelectric device according to claim 1,

wherein the first electrode or the second electrode comprises molybdenum; and
wherein the molybdenum is patterned using an isotropic etch.

~~14.~~13. A method of forming a piezoelectric device, the method comprising:

forming a layered stacked arrangement anchored to the substrate, the layered stacked arrangement comprising:

a piezoelectric layer;

a first electrode on a first side of the piezoelectric layer; and

a second electrode on a second side of the piezoelectric layer opposite the first side;

wherein the piezoelectric layer comprises a first region comprising one or more dipole domains of a first type;

wherein the piezoelectric layer comprises a second region comprising one or more dipole domains of a second type;

wherein the first electrode is at least partially in contact with the first region and at least partially in contact with the second region;

wherein the second electrode is at least partially in contact with the first region and at least partially in contact with the second region;

wherein the piezoelectric device is a sensor or an actuator; ~~and~~

~~wherein during operation, at least 50% of the first region is configured to have a positive curvature and at least 50% of the second region is configured to have a negative curvature~~wherein the piezoelectric device further comprises a gap material between the first region and the second region; and

wherein the gap material has a dielectric constant lower than a dielectric constant of a piezoelectric material of the piezoelectric layer.

~~15.~~14. The method according to claim ~~14~~13,

wherein the first electrode is formed on a substrate before forming the piezoelectric layer;

wherein the method comprises forming one or more temporary electrodes on the second side of the piezoelectric layer before forming the second

electrode; wherein the method also comprises applying one or more potential differences between the one or more first electrodes and one or more temporary electrodes so that the piezoelectric layer comprises the first region and the second region; and

wherein the one or more temporary electrodes are removed before forming the second electrode, or the one or more temporary electrodes are modified to form the second electrode.

~~16.~~15. The method according to claim ~~15~~14,

wherein the piezoelectric layer is initially unpoled.

~~17.~~16. The method according to claim ~~15~~14,

wherein the piezoelectric layer initially comprises dipole domains of the first type or of the second type.

~~18.~~17. The method according to claim ~~15~~14,

wherein forming the piezoelectric layer comprises using a shadow mask for allowing electrical access to the first electrode.

~~19.~~18. The method according to claim ~~15~~14,

wherein the method further comprises etching the piezoelectric layer before forming the second electrode for allowing electrical access to the first electrode.

~~20.~~19. The method according to claim ~~14~~13,

wherein the substrate is patterned before forming the piezoelectric stack; or wherein the substrate is a silicon-on-insulator (SOI) wafer.