CLAIMS

1. An optical device including:

   an elongate substrate;

   an emitter portion at a distal end portion of the elongate substrate, the emitter portion configured to emit light; and

   an actuator portion at a proximal end portion of the elongate substrate opposite the distal end portion of the elongate substrate;

   wherein the emitter portion comprises a first electrode, a second electrode, and an active layer between the first electrode and the second electrode so that the light is emitted due to an increase in a temperature of the active layer upon application of a first potential difference between the first electrode and the second electrode;

   wherein the active layer is patterned to form a photonic crystal layer for enhancing a directionality of the emitted light; and

   wherein the actuator portion comprises a stacked arrangement comprising a first electrical pad, a second electrical pad, and a piezoelectric layer between the first electrical pad and the second electrical pad such that the actuator portion is configured to deform the elongate substrate upon application of a second potential difference between the first electrical pad and the second electrical pad, thereby moving the emitter portion.

2. The optical device according to claim 1,

   wherein the elongate substrate comprises dopants of a first charge polarity; and.

   wherein the active layer comprises dopants of a second charge polarity opposite the first charge polarity.

3. The optical device according to claim 2,

   wherein the elongate substrate is p-doped; and

   wherein the active layer is n-doped.

4. The optical device according to claim 3,
wherein a portion of the active layer is in contact with the elongate substrate to form a p-n junction.

5. The optical device according to claim 1, further comprising:
an insulator layer on the elongate substrate such that a first portion of the insulator layer is between the emitter portion and the elongate substrate, and a second portion of the insulator layer is between the actuator portion and the elongate substrate.

6. The optical device according to claim 5,
wherein the insulator layer comprises silicon oxide.

7. The optical device according to claim 1,
wherein the piezoelectric layer comprises lead zirconate titanate, aluminium nitride or scandium aluminum nitride.

8. The optical device according to claim 1,
wherein the active layer comprises a plurality of holes extending from a first surface of the active layer to a second surface of the active layer opposite the first surface.

9. The optical device according to claim 8,
wherein the plurality of holes forms a periodic array.

10. The optical device according to claim 8,
wherein a diameter of a hole of the plurality of holes is of a value selected from a range from 0.5 μm to 2 μm.

11. The optical device according to claim 1,

wherein the light emitted by the emitter portion is within 1 steradian.

12. The optical device according to claim 1,

wherein the emitter portion remains undeformed during the deformation of the elongate substrate.

13. A gas sensor for sensing a gas, the gas sensor comprising:

a detector portion comprising:

a substrate;

a waveguide over the substrate; and

a grating coupler on the waveguide;

an optical device comprising:

an elongate substrate;

an emitter portion at a distal end portion of the elongate substrate, the emitter portion configured to emit light; and

an actuator portion at a proximal end portion of the elongate substrate opposite the distal end portion of the elongate substrate;

wherein the emitter portion comprises a first electrode, a second electrode, and an active layer between the first electrode and the second electrode so that the light is emitted due to an increase in a temperature of the active layer upon application of a first potential difference between the first electrode and the second electrode;

wherein the active layer is patterned to form a photonic crystal layer for enhancing a directionality of the emitted light; and

wherein the actuator portion comprises a stacked arrangement comprising a first electrical pad, a second electrical pad, and a piezoelectric layer between the first electrical pad and the second electrical pad such that the actuator portion is configured to deform the elongate substrate upon

application of a second potential difference between the first electrical pad and the second electrical pad, thereby moving the emitter portion;

wherein the gas sensor further comprises:

a support configured to suspend the optical device over the detector portion;

wherein the emitter portion faces the detector portion; and

wherein the gas sensor is configured such that a wavelength of the light that is received by the detector portion is based on the movement of the emitter portion.

14. The gas sensor according to claim 13, further comprising:

a cladding layer on the substrate;

wherein the waveguide is on the cladding layer.

15. The gas sensor according to claim 13, further comprising:

a detector optically coupled to the waveguide;

wherein the detector is configured to detect the light travelling along the waveguide to the detector.

16. The gas sensor according to claim 15, further comprising:

a feedback circuit in electrical communication with the detector and the actuator portion;

wherein the detector is configured to generate a feedback electrical signal upon the detector detecting the light;

wherein the feedback circuit is further configured to generate an adjustment electrical signal based on the feedback electrical signal; and

wherein the actuator portion is configured to deform the elongate substrate based on the adjustment electrical signal.

17. A method of forming an optical device, the method comprising:

forming an emitter portion at a distal end portion of an elongate substrate, the emitter portion configured to emit light; and

forming an actuator portion at a proximal end portion of the elongate substrate opposite the distal end portion of the elongate substrate;

wherein the emitter portion comprises a first electrode, a second electrode, and an active layer between the first electrode and the second electrode so that the light is emitted due to an increase in a temperature of the active layer upon application of a first potential difference between the first electrode and the second electrode;

wherein the active layer is patterned to form a photonic crystal layer for enhancing a directionality of the emitted light; and

wherein the actuator portion comprises a stacked arrangement comprising a first electrical pad, a second electrical pad, and a piezoelectric layer between the first electrical pad and the second electrical pad such that the actuator portion is configured to deform the elongate substrate upon application of a second potential difference between the first electrical pad and the second electrical pad, thereby moving the emitter portion.

18. A method of forming a gas sensor, the method comprising:

forming a detector portion comprising:

a substrate;

a waveguide over the substrate; and

a grating coupler on the waveguide;

forming an optical device comprising:

an elongate substrate;

an emitter portion at a distal end portion of the elongate substrate, the emitter portion configured to emit light; and

an actuator portion at a proximal end portion of the elongate substrate opposite the distal end portion of the elongate substrate;

wherein the emitter portion comprises a first electrode, a second electrode, and an active layer between the first electrode and the second electrode so

that the light is emitted due to an increase in a temperature of the active layer upon application of a first potential difference between the first electrode and the second electrode;

wherein the active layer is patterned to form a photonic crystal layer for enhancing a directionality of the emitted light; and

wherein the actuator portion comprises a stacked arrangement comprising a first electrical pad, a second electrical pad, and a piezoelectric layer between the first electrical pad and the second electrical pad such that the actuator portion is configured to deform the elongate substrate upon application of a second potential difference between the first electrical pad and the second electrical pad, thereby moving the emitter portion;

wherein the method further comprises:

forming a support configured to suspend the optical device over the detector portion;

wherein the emitter portion faces the detector portion; and

wherein the gas sensor is configured such that a wavelength of the light that is received by the detector portion is based on the movement of the emitter portion.

19. A method of operating an optical device, the method comprising:

activating an emitter portion at a distal end portion of an elongate substrate to emit light by applying a first potential difference between a first electrode and a second electrode so that a temperature of an active layer between the first electrode and the second electrode increases to emit the light, the active layer being patterned to form a photonic crystal layer for enhancing a directionality of the emitted light; and

activating an actuator portion at a proximal end portion of the elongate substrate opposite the distal end portion of the elongate substrate to deform the elongate substrate by applying a second potential difference between a first electrical pad and a second electrical pad of a stack arrangement, the stacked arrangement

further comprising a piezoelectric layer between the first electrical pad and the second electrical pad, to move the emitter portion.

20. A method of operating a gas sensor to sense a gas, the method comprising:

operating an optical device suspended over a detector portion by a support with an emitter portion of the optical device facing the detector portion, so that a wavelength of light that is received by the detector portion is based on the movement of the emitter portion;

wherein the optical device comprises:

an elongate substrate;

the emitter portion at a distal end portion of the elongate substrate, the emitter portion configured to emit the light; and

an actuator portion at a proximal end portion of the elongate substrate opposite the distal end portion of the elongate substrate;

wherein the emitter portion comprises a first electrode, a second electrode, and an active layer between the first electrode and the second electrode so that the light is emitted due to an increase in a temperature of the active layer upon application of a first potential difference between the first electrode and the second electrode;

wherein the active layer is patterned to form a photonic crystal layer for enhancing a directionality of the emitted light; and

wherein the actuator portion comprises a stacked arrangement comprising a first electrical pad, a second electrical pad, and a piezoelectric layer between the first electrical pad and the second electrical pad such that the actuator portion is configured to deform the elongate substrate upon application of a second potential difference between the first electrical pad and the second electrical pad, thereby moving the emitter portion; and

wherein the detector portion comprises:

a substrate;

a waveguide over the substrate; and

a grating coupler on the waveguide.