Claims

1. An optical device, comprising:

an optically resonant structure formed in a planar device layer of a semiconductor chip, the optically resonant structure including one or more semiconductor materials including silicon, the optically resonant structure having a ring shape defined by an outer wall and an inner wall, the outer wall and the inner wall positioned concentrically about a center of the ring shape;

a plurality of n-type regions formed within the optically resonant structure, each of the plurality of n-type regions occupying a corresponding volume within the optically resonant structure that is subtended by a first corresponding angle measured azimuthally about a vertical centerline of the ring shape of the optically resonant structure, the vertical centerline extending through the center of the ring shape and substantially perpendicular to at least one of the bottom and top surfaces of the planar device layer, the corresponding volume of each of the plurality of n-type regions positioned within a light propagation path of a resonant mode of the optically resonant structure;

a plurality of p–type regions formed within the optically resonant structure, each of the plurality of p-type regions occupying a corresponding volume within the optically resonant structure that is subtended by a second corresponding angle measured azimuthally about the vertical centerline of the ring shape of the optically resonant structure, each of the plurality of p-type regions located between and interfacing with a neighboring pair of n-type regions of the plurality of n-type regions so as to form a plurality of lateral semiconductor junctions across the light propagation path of the resonant mode of the optically resonant structure, each of the plurality of lateral semiconductor junctions existing within a corresponding substantially vertical

plane extending radially outward from the vertical centerline of the ring shape of the optically resonant structure;

a first plurality of contacts electrically and respectively connected to the plurality of n-type regions, each of the first plurality of contacts electrically connected to a first electrical conduit, each of the first plurality of contacts positioned to contact a corresponding one of the plurality of n-type regions at a corresponding location away from the light propagation path of the resonant mode of the optically resonant structure; and

a second plurality of contacts electrically and respectively connected to the plurality of p-type regions, each of the second plurality of contacts electrically connected to a second electrical conduit, each of the second plurality of contacts positioned to contact a corresponding one of the plurality of p-type regions at a corresponding location away from the light propagation path of the resonant mode of the optically resonant structure.

2. The optical device of claim 1, wherein each of the outer wall and the inner wall extends continuously from a top cladding to a bottom cladding.

3. The optical device of claim 1, wherein a height of either the outer wall or the inner wall defines a maximum height of the optically resonant structure.

4. The optical device of claim 1, wherein each of the outer wall and the inner wall extends continuously from a bottom surface of the planar device layer to a top surface of the planar device layer.

5. The optical device of claim 1, wherein each of the plurality of n-type regions extends radially from the inner wall to the outer wall, and wherein each of the plurality of p-type regions extends radially from the inner wall to the outer wall.

6. The optical modulator of claim 1, wherein the first plurality of contacts and the second plurality of contacts are disposed alongside the inner wall.

7. The optical device of claim 1, wherein the first plurality of contacts and the second plurality of the contacts are disposed in closer proximity to the inner wall than to the outer wall.

8. The optical device of claim 1, wherein each of the plurality of n-type regions extends over less than a radial distance as measured from the outer wall to the inner wall, and wherein each of the plurality of p-type regions extends over less than the radial distance as measured from the outer wall to the inner wall.

9. The optical device of claim 1, wherein each one of the plurality of n-type regions forms at least one lateral semiconductor junction of the plurality of lateral semiconductor junctions.

10. The optical device of claim 1, wherein each one of the plurality of p-type regions forms at least one lateral semiconductor junction of the plurality of lateral semiconductor junctions.

11. The optical device of claim 1, wherein each of the plurality of n-type regions extends radially outside of the outer wall, and wherein each of the plurality of p-type regions extends radially outside of the outer wall.

12. The optical device of claim 1, wherein each of the plurality of n-type regions extends to at least one of a bottom surface of the planar device layer and a top surface of the planar device layer.

13. The optical device of claim 1, wherein each of the plurality of n-type regions extends to both a bottom surface of the planar device layer and a top surface of the planar device layer.

14. The optical device of claim 1, wherein each of the plurality of lateral semiconductor junctions extends from a bottom surface of the planar device layer to a top surface of the planar device layer.

15. The optical device of claim 14, wherein each of the plurality of lateral semiconductor junctions extends from the inner wall to the outer wall.

16. The optical device of claim 1, wherein the optically resonant structure has a height that is less than or equal to 100 nm.

17. The optical device of claim 1, wherein the optically resonant structure includes at least one of a modulator and a detector.

18. An optical device, comprising:

an optically resonant structure formed in a planar device layer of a microchip, the optically resonant structure including one or more semiconductor materials including silicon, the optically resonant structure having a ring shape defined by an outer wall and an inner wall, the outer wall and the inner wall positioned concentrically about a center of the ring shape;

a plurality of n-type regions formed within the optically resonant structure, each of the plurality of n-type regions occupying a corresponding volume within the optically resonant structure that is subtended by a corresponding angle measured azimuthally about a vertical centerline of the ring shape of the optically resonant structure, the vertical centerline extending through the center of the ring shape and substantially perpendicular to at least one of the bottom and top surfaces of the planar device layer, the corresponding volume of each of the plurality of n-type regions positioned within a light propagation path of a resonant mode of the optically resonant structure;

a plurality of p–type regions formed within the optically resonant structure, each of the plurality of p-type regions occupying a corresponding volume within the optically resonant structure that is subtended by a corresponding angle measured azimuthally about the vertical centerline of the ring shape of the optically resonant structure, each of the plurality of p-type regions located between and interfacing with a neighboring pair of n-type regions of the plurality of n-type regions so as to form a plurality of lateral semiconductor junctions across the light propagation path of the resonant mode of the optically resonant structure, each of the plurality of

lateral semiconductor junctions existing within a respective substantially vertical plane extending radially outward from the vertical centerline of the ring shape of the optically resonant structure; and

an optical waveguide bus having a curved portion optically coupled to the optically resonant structure, the optical waveguide bus being outside the outer wall of the optically resonant structure.

19. The optical device of claim 18, wherein the optical waveguide bus is configured to mainly excite a fundamental optical resonant mode of the optically resonant structure at an operating wavelength.

20. An optical device, comprising:

an optically resonant structure formed in a planar layer of a semiconductor chip, the optically resonant structure including one or more semiconductor materials including silicon, the optically resonant structure having a ring shape defined by an outer wall and an inner wall, the outer wall and the inner wall positioned concentrically about a center of the ring shape, wherein the optically resonant structure has a height that is less than or equal to 100 nm;

a plurality of n-type regions formed within the optically resonant structure, each of the plurality of n-type regions occupying a corresponding volume within the optically resonant structure that is subtended by a first angle measured azimuthally about a vertical centerline of the ring shape of the optically resonant structure, the vertical centerline extending through the center of the ring shape and substantially perpendicular to at least one of the bottom and top surfaces of the planar device layer, the corresponding volume of each of the plurality of n-type regions

positioned within a light propagation path of a resonant mode of the optically resonant structure; and

a plurality of p–type regions formed within the optically resonant structure, each of the plurality of p-type regions occupying a respective volume within the optically resonant structure that is subtended by a second angle measured azimuthally about the vertical centerline of the ring shape of the optically resonant structure, each of the plurality of p-type regions located between and interfacing with a neighboring pair of n-type regions of the plurality of n-type regions so as to form a plurality of lateral semiconductor junctions across the light propagation path of the resonant mode of the optically resonant structure, each of the plurality of lateral semiconductor junctions existing within a corresponding substantially vertical plane extending radially outward from the vertical centerline of the ring shape of the optically resonant structure.

21. The optical device of claim 20, further comprising:

a structure formed from a light absorbing material at an operating wavelength and defined within the outer wall of the optically resonant structure, wherein the light absorbing material includes germanium.

22. The optical device of claim 20, wherein each of the outer wall and the inner wall extends continuously from a top cladding to a bottom cladding.

23. The optical modulator device of claim 20, wherein a height of either the outer wall or the inner wall defines a maximum height of the optically resonant structure.

24. The optical device of claim 20, wherein each of the plurality of n-type regions extends radially from the inner wall to the outer wall, and wherein each of the plurality of p-type regions extends radially from the inner wall to the outer wall.

25. The optical device of claim 19, wherein the optical waveguide bus has a first angular propagation constant at an operating wavelength and the resonant mode of the optically resonant structure has a second angular propagation constant at the operating wavelength, wherein the first angular propagation constant substantially matches the second angular propagation constant.

26. The optical device of claim 18, wherein the optical waveguide bus is a first optical waveguide bus, the optical device further comprising a second optical waveguide bus optically coupled to the optically resonant structure.

27. The optical device of claim 18, wherein each of the outer wall and the inner wall extends continuously from a top cladding to a bottom cladding.

28. The optical device of claim 18, wherein a height of either the outer wall or the inner wall defines a maximum height of the optically resonant structure.

29. The optical device of claim 1, further comprising:

a transistor formed in the planar device layer of the semiconductor chip.

30. The optical device of claim 18, further comprising:

a transistor formed in the planar device layer of the semiconductor chip.

31. The optical device of claim 20, further comprising:

a transistor formed in the planar device layer of the semiconductor chip.

32. The optical device of claim 1, wherein:

the first corresponding angle is substantially the same for each of the plurality of n-type regions occupying the corresponding volume within the optically resonant structure;

the second corresponding angle is substantially the same for each of the plurality of p-type regions occupying the corresponding volume within the optically resonant structure; and

the first corresponding angle and the second corresponding angle are substantially the same.