

CLAIMS

1. An optical fiber with an acoustically sensitive fiber Bragg grating, comprising:
an optical fiber core, wherein a fiber Bragg grating is formed in the optical fiber core; and
a cladding material disposed on and surrounding at least a portion of the optical fiber core,
wherein the cladding material has at least one material property associated therewith, the at least one material property being selected from the group consisting of a smaller Young's modulus than a Young's modulus of the optical fiber core, a larger photo-elastic coefficient than a photo-elastic coefficient of the optical fiber core, and combinations thereof.
2. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 1, wherein a region of the optical fiber core has a diameter which is less than a diameter of a remainder of the optical fiber core.
3. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 2, wherein a recess is formed in an outer surface of the optical fiber core, and wherein the cladding material fills the recess.
4. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 3, wherein the recess is an annular recess.

5. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 1, wherein the cladding material is selected from the group consisting of polyvinylidene fluoride, polystyrene, parylene, and benzocyclobutene.

6. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 1, further comprising a reflector formed in the optical fiber core, the reflector being spaced apart from the fiber Bragg grating.

7. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 6, wherein a region of the optical fiber core between the fiber Bragg grating and the reflector has a diameter which is less than a diameter of a remainder of the optical fiber core.

8. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 7, wherein a recess is formed in an outer surface of the optical fiber core, the recess being aligned with the region of the optical fiber core between the fiber Bragg grating and the reflector, and wherein the cladding material fills the recess.

9. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 8, wherein the recess is an annular recess.

10. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 6, wherein a region between the fiber Bragg grating and the reflector is at least partially filled with the cladding material.

11. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 10, wherein the region between the fiber Bragg grating and the reflector which is at least partially filled with the cladding material has a diameter which is less than a diameter of the optical fiber core.

12. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 11, wherein a recess is formed in an outer portion of the region between the fiber Bragg grating and the reflector which is at least partially filled with the cladding material, and wherein a secondary cladding material fills the recess, the secondary cladding material having a smaller refractive index than the refractive index of the cladding material.

13. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 10, wherein the region between the fiber Bragg grating and the reflector which is at least partially filled with the cladding material has a diameter which is greater than a diameter of the optical fiber core.

14. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 10, wherein the region between the fiber Bragg grating and the reflector which is at least partially filled with the cladding material is defined by a pair of convex surfaces respectively facing the fiber Bragg grating and the reflector.

15. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 10, wherein the region between the fiber Bragg grating and the reflector which is at least partially filled with the cladding material is defined by a concave surface facing one of the fiber Bragg grating and the reflector and a convex surface facing the other of the fiber Bragg grating and the reflector.

16. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 10, wherein the region between the fiber Bragg grating and the reflector which is at least partially filled with the cladding material is defined by a planar surface facing one of the fiber Bragg grating and the reflector and a convex surface facing the other of the fiber Bragg grating and the reflector.

17. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 6, wherein the cladding material is selected from the group consisting of polyvinylidene fluoride, polystyrene, parylene, and benzocyclobutene.

18. The optical fiber with an acoustically sensitive fiber Bragg grating as recited in claim 6, wherein the reflector is selected from the group consisting of a mirror and another fiber Bragg grating.

19. An ultrasound sensor, comprising:
at least one optical fiber embedded in a polymer layer;
a fiber Bragg grating and a reflector formed in an optical fiber core of the at least one optical fiber, wherein the fiber Bragg grating and the reflector are spaced apart from one another;

a cladding material disposed on and surrounding at least a portion of the optical fiber core, wherein the cladding material has at least one material property associated therewith, the at least one material property being selected from the group consisting of a smaller Young's modulus than a Young's modulus of the optical fiber core, a larger photo-elastic coefficient than a photo-elastic coefficient of the optical fiber core, and combinations thereof;

a backing layer; and

an acoustic matching layer,

wherein the polymer layer and the at least one optical fiber are sandwiched between the backing layer and the acoustic matching layer.

20. The ultrasound sensor as recited in claim 19, wherein the at least one optical fiber comprises a linear array of the optical fibers.

21. The ultrasound sensor as recited in claim 20, wherein the at least one optical fiber comprises a cylindrically distributed array of the optical fibers within the polymer layer.

22. The ultrasound sensor as recited in claim 21, wherein the cylindrically distributed array of the optical fibers are circumferentially distributed.

23. The ultrasound sensor as recited in claim 19, further comprising at least one acoustic energy generating transducer positioned adjacent to the at least one optical fiber.

24. The ultrasound sensor as recited in claim 23, wherein the at least one optical fiber comprises a cylindrically distributed array of the optical fibers, and wherein the at least one acoustic energy generating transducer comprises an array of the acoustic energy generating transducers annularly surrounding the cylindrically distributed array of the optical fibers and the polymer layer.

25. The ultrasound sensor as recited in claim 19, further comprising at least one array of photoacoustic fiber bundles positioned adjacent to the at least one optical fiber.

26. The ultrasound sensor as recited in claim 19, further comprising an array of photoacoustic fiber bundles embedded in the polymer layer.

27. The ultrasound sensor as recited in claim 26, wherein the at least one optical fiber comprises array of the optical fibers, and wherein the array of photoacoustic fiber bundles and the array of the optical fibers are each cylindrically distributed within the polymer layer.

28. The ultrasound sensor as recited in claim 27, wherein the array of the optical fibers and the array of photoacoustic fiber bundles are each circumferentially distributed.

29. The ultrasound sensor as recited in claim 19, further comprising:

a light source for producing an initial light beam having a plurality of wavelengths associated therewith;

an optical circulator having first, second and third ports, the first port being in optical communication with the light source;

a first wavelength division multiplexing splitter in optical communication with the second port of the optical circulator, the first wavelength division multiplexing splitter dividing the initial light beam into optical signals each having one of the wavelengths associated therewith, wherein the at least one optical fiber comprises an array of the optical fibers, and wherein the first wavelength division multiplexing splitter is in optical communication with the array of the optical fibers for respectively transmitting the optical signals thereto;

a wavelength division multiplexing combiner in optical communication with the array of the optical fibers for receiving sensed signals therefrom, the wavelength division multiplexing combiner combining the sensed signals into a sensed light beam, the wavelength division multiplexing combiner being in optical communication with the second port of the optical circulator;

a second wavelength division multiplexing splitter in optical communication with the third port of the optical circulator for receiving the initial light beam and the sensed light beam and dividing each into individual wavelength components; and

a photodetector array in optical communication with the second wavelength division multiplexing splitter for receiving the individual wavelength components of the sensed light beam, wherein detected phase shifts are indicative of sensed acoustic signals.

30. The ultrasound sensor as recited in claim 29, further comprising at least one acoustic energy generating transducer positioned adjacent to an array of the optical fibers.

31. The ultrasound sensor as recited in claim 30, wherein the array of the optical fibers comprises a cylindrically distributed array of the optical fibers, and wherein the at least one acoustic energy generating transducer comprises an array of acoustic energy generating transducers annularly surrounding the array of the optical fibers and the polymer layer.

32. The ultrasound sensor as recited in claim 31, further comprising an acoustic lens positioned adjacent to the acoustic matching layer.

33. The ultrasound sensor as recited in claim 19, wherein the reflector of the at least one optical fiber is selected from the group consisting of a mirror and another fiber Bragg grating.

34. An optical chip with an acoustically sensitive fiber Bragg grating, comprising:
a substrate;

an optically transparent layer formed on the substrate, wherein the optically transparent layer defines a core region, and wherein a fiber Bragg grating and a reflector are formed in the core region, the fiber Bragg grating and the reflector being spaced apart from one another; and

a cladding material disposed on and surrounding at least a portion of the core region such that the core region is at least partially sandwiched between the cladding material and the substrate, wherein the cladding material has at least one material property associated therewith, the at least

one material property being selected from the group consisting of a smaller Young's modulus than a Young's modulus of the core region, a larger photo-elastic coefficient than a photo-elastic coefficient of the core region, and combinations thereof.

35. The optical chip with an acoustically sensitive fiber Bragg grating as recited in claim 34, wherein a portion of the core region between the fiber Bragg grating and the reflector has a width which is less than a width of a remainder of the core region.

36. The optical chip with an acoustically sensitive fiber Bragg grating as recited in claim 35, wherein a recess is formed in at least one outer edge of the core region, the recess being aligned with the portion of the core region between the fiber Bragg grating and the reflector, and wherein the cladding material fills the recess.

37. The optical chip with an acoustically sensitive fiber Bragg grating as recited in claim 34, wherein a region between the fiber Bragg grating and the reflector is at least partially filled with the cladding material.

38. The optical chip with an acoustically sensitive fiber Bragg grating as recited in claim 37, wherein the region between the fiber Bragg grating and the reflector which is at least partially filled with the cladding material has a width which is less than a width of the core region.

39. The optical chip with an acoustically sensitive fiber Bragg grating as recited in claim 38, wherein a recess is formed in at least one outer edge of the region between the fiber Bragg

grating and the reflector which is at least partially filled with the cladding material, and wherein a secondary cladding material fills the recess, the secondary cladding material having a smaller refractive index than the refractive index of the cladding material.

40. The optical chip with an acoustically sensitive fiber Bragg grating as recited in claim 37, wherein the region between the fiber Bragg grating and the reflector which is at least partially filled with the cladding material has a width which is greater than a width of the core region.

41. The optical chip with an acoustically sensitive fiber Bragg grating as recited in claim 37, wherein the region between the fiber Bragg grating and the reflector which is at least partially filled with the cladding material is defined by a pair of convex surfaces respectively facing the fiber Bragg grating and the reflector.

42. The optical chip with an acoustically sensitive fiber Bragg grating as recited in claim 37, wherein the region between the fiber Bragg grating and the reflector which is at least partially filled with the cladding material is defined by a concave surface facing one of the fiber Bragg grating and the reflector and a convex surface facing the other of the fiber Bragg grating and the reflector.

43. The optical chip with an acoustically sensitive fiber Bragg grating as recited in claim 37, wherein the region between the fiber Bragg grating and the reflector which is at least partially filled with the cladding material is defined by a planar surface facing one of the fiber Bragg grating and the reflector and a convex surface facing the other of the fiber Bragg grating and the reflector.

44. The optical chip with an acoustically sensitive fiber Bragg grating as recited in claim 34, wherein the cladding material is selected from the group consisting of polyvinylidene fluoride, polystyrene, parylene, and benzocyclobutene.

45. The optical chip with an acoustically sensitive fiber Bragg grating as recited in claim 34, wherein the reflector is selected from the group consisting of a mirror and another fiber Bragg grating.