CLAIMS

1. An acousto-optic imaging system comprising:

at least one transducer configured to transmit an ultrasound signal having a fundamental frequency *f*; and

at least one optical sensor configured to produce one or more optical responses upon receiving harmonic or subharmonic ultrasound echoes corresponding to the transmitted ultrasound signal, wherein the at least one optical sensor has a bandwidth ranging from at least *f*/*M* to *Nf*, where *M* and *N* are integers greater than 1.

2. The system of claim 1, wherein the at least one optical sensor is configured to produce at least a portion of the one or more optical responses upon receiving ultrasound echoes having a super-harmonic frequency of at least *Qf*, where *Q* is an integer 3 or greater.

3. The system of claim 1, wherein the at least one optical sensor is configured to produce at least a portion of the one or more optical responses upon receiving ultrasound echoes having a frequency of *2f* or *f*.

~~4. The system of claim 1, wherein the at least one optical sensor is configured to produce at least a portion of the one or more optical responses upon receiving ultrasound echoes having an ultra-harmonic frequency of at least *Pf*, where *P* is a non-integer greater than 1.~~

~~5. The system of claim 4, wherein the at least one optical sensor is configured to produce at least a portion of the one or more optical responses upon receiving ultrasound echoes having an ultra-harmonic frequency of at least *Pf*, where *P* is a non-integer rational number greater than 1.~~

~~6~~4. The system of claim 1, wherein the at least one optical sensor is configured to produce at least a portion of the one or more optical responses upon receiving ultrasound echoes having a subharmonic frequency of *f*/*R*, where *R* is a number greater than 1.

~~7~~5. The system of claim 1, wherein the fundamental frequency *f* is a first fundamental frequency f_1, and the at least one transducer is configured to generate a second ultrasound signal having a second fundamental frequency f_2.

~~8~~6. The system of claim ~~7~~5, wherein the at least one optical sensor is configured to produce at least a portion of the one or more optical responses upon receiving ultrasound echoes that correspond to a frequency of one or more linear combinations $nf_1 + mf_2$, wherein n and m are integers such that $nf_1 + mf_2$ is a positive number.

~~9. The system of claim 8, wherein *n* and *m* are positive integers.~~

~~10~~7. The system of claim 1, further comprising a computer-readable medium storing instructions to generate an image based on the one or more optical responses of the at least one optical sensor.

~~11~~8. The system of claim 1, further comprising a computer-readable medium storing instructions to generate an image based on a change in the one or more optical responses of the at least one optical sensor.

~~12. The system of claim 11, wherein the computer-readable medium stores further instructions to:~~

~~calculate a magnitude of each ultrasound echo at the at least one optical sensor based on the change; and~~

~~convert the magnitude of each ultrasound echo to a pixel value for display.~~

~~13~~9. The system of claim ~~11~~8, wherein the change indicates a spectral shift and each optical response includes at least one spectral resonance feature with a full-width at half-maxima (FWHM) that is smaller than the spectral shift.

~~14. The system of claim 1, wherein the at least one transducer includes at least one of a piezoelectric transducer, a capacitive micromachined ultrasonic transducer (CMUT), a polymer thick film (PTF) transducer, a photoacoustic transducer, and a piezoelectric micromachined ultrasound transducer (PMUT).~~

~~15. The system of claim 1, wherein the at least one optical sensor is coupled to one or more optical waveguides configured to propagate the plurality of optical signals to one or more optical detectors.~~

~~16. The system of claim 1, wherein the at least one optical sensor comprises a closed loop of a material that is optically transparent to the one or more optical responses.~~

~~17~~10. The system of claim 1, wherein the at least one optical sensor is configured to have an effective refractive index and a wall thickness that enable propagation of a set of whispering gallery modes (WGMs) in the at least one optical sensor.

~~18~~11. The system of claim ~~17~~10, wherein the at least one optical sensor is embedded in a polymer structure with an effective refractive index lower than the effective refractive index of the at least one optical sensor.

~~19. The system of claim 17, wherein the effective refractive index of at least one optical sensor changes due to a photo-elastic effect of the at least one optical sensor upon receipt of the ultrasound echoes.~~

~~20~~12. A method for acousto-optic imaging comprising:

transmitting to a medium an ultrasound signal via at least one transducer having a fundamental frequency *f*; and

producing one or more optical responses via at least one optical sensor upon receiving harmonic or subharmonic ultrasound echoes corresponding to the transmitted ultrasound signal, wherein the at least one optical sensor has a bandwidth ranging from at least *f*/*M* to *Nf*, where *M* and *N* are integers greater than 1.

~~21~~13. The method of claim ~~20~~12, wherein the at least one optical sensor is configured to produce at least a portion of the one or more optical responses upon receiving ultrasound echoes having a superharmonic frequency of at least *Qf*, where *Q* is an integer 3 or greater.

~~22~~14. The method of claim ~~20~~12, wherein the at least one optical sensor is configured to produce at least a portion of the one or more optical responses upon receiving ultrasound echoes having a frequency of *2f* or *f*.

~~23. The method of claim 20, wherein the at least one optical sensor is configured to produce at least a portion of the one or more optical responses upon receiving ultrasound echoes having an ultra-harmonic frequency of at least *Pf*, where *P* is a non-integer greater than 1.~~

~~24. The method of claim 23, wherein the at least one optical sensor is configured to produce at least a portion of the one or more optical responses upon receiving ultrasound echoes having an ultra-harmonic frequency of at least *Pf*, where *P* is a non-integer rational number greater than 1.~~

~~25~~15. The method of claim ~~20~~12, wherein the at least one optical sensor is configured to produce at least a portion of the one or more optical responses upon receiving ultrasound echoes having a subharmonic frequency of *f/R*, where *R* is an integer 2 or greater.

~~26~~16. The method of claim ~~20~~12, wherein the fundamental frequency *f* is a first fundamental frequency f_1, and the at least one transducer is configured to generate a second ultrasound signal having a second fundamental frequency f_2.

~~27~~17. The method of claim ~~26~~16, wherein the at least one optical sensor is configured to produce at least a portion of the one or more optical responses upon receiving ultrasound echoes that correspond to a frequency of one or more linear combinations $nf_1 + mf_2$, wherein *n* and *m* are integers such that $nf_1 + mf_2$ is a positive number.

~~28. The method of claim 27, wherein *n* and *m* are positive integers.~~

~~29. The method of claim 20, further comprising:~~

~~generating, via a computer-readable medium, an image based on the one or more optical responses of the at least one optical sensor.~~

~~30~~18. The method of claim ~~20~~12, further comprising:

generating, via a computer-readable medium, an image based on a change in the one or more optical responses of the at least one optical sensor.

~~31. The method of claim 30, further comprising:~~

~~calculating, via a computer-readable medium, a magnitude of each ultrasound echo at the at least one optical sensor based on the change; and~~

~~converting, via a computer-readable medium, the magnitude of each ultrasound echo to a pixel value for display.~~

~~32~~19. The method of claim ~~30~~18, wherein the change indicates a spectral shift and each optical response includes at least one spectral resonance feature with a full-width at half-maxima (FWHM) that is smaller than the spectral shift.

~~33. The method of claim 20, wherein the at least one transducer includes at least one of a piezoelectric transducer, a capacitive micromachined ultrasonic transducer (CMUT), a polymer thick film (PTF) transducer, a photoacoustic transducer, and a piezoelectric micromachined ultrasound transducer (PMUT).~~

~~34. The method of claim 20, wherein the at least one optical sensor is coupled to one or more optical waveguides configured to propagate the plurality of optical signals to one or more optical detectors.~~

~~35. The method of claim 20, wherein the at least one optical sensor comprises a closed loop of a material that is optically transparent to the one or more optical responses.~~

~~36. The method of claim 20, wherein the at least one optical sensor is configured to have an effective refractive index and a wall thickness that enable propagation of a set of whispering gallery modes (WGMs) in the at least one optical sensor.~~

~~37. The method of claim 36, wherein the at least one optical sensor is embedded in a polymer structure with an effective refractive index lower than the effective refractive index of the at least one optical sensor.~~

~~38. The method of claim 36, wherein the effective refractive index of the at least one optical sensor changes due to a photo-elastic effect upon receipt of the plurality of ultrasound echoes.~~

~~39. The method of claim 20, wherein the medium is a non-linear medium.~~

~~40. The method of claim 20, wherein the medium is a biological tissue.~~

~~41~~20. A method of acousto-optic imaging comprising:

transmitting to a medium one or more ultrasound signals having one or more fundamental frequencies;

detecting at least one change in an optical response of one or more optical detectors, wherein the at least one change in the optical response is produced upon receiving ultrasound echoes corresponding to the one or more ultrasound signals, wherein at least a portion of the received ultrasound echoes has a frequency that is a super-harmonic frequency of the one or more fundamental frequencies, a subharmonic frequency of the one or more fundamental frequencies, an ultra-harmonic frequency of the one or more fundamental frequencies, or a linear combination of the one or more fundamental frequencies; and

generating an image of the medium based on the detected change in the optical response.

~~42. The method of claim 41, further comprising:~~

~~generating, via a computer-readable medium, an image based on the one or more optical responses of the at least one optical sensor.~~

~~43. The method of claim 41, further comprising:~~

~~generating, via a computer-readable medium, an image based on a change in the one or more optical responses of the at least one optical sensor.~~

~~44. The method of claim 43, further comprising:~~

~~calculating, via a computer-readable medium, a magnitude of each ultrasound echo at the at least one optical sensor based on the change; and~~

converting, via a computer-readable medium, the magnitude of each ultrasound echo to a pixel value for display.

45. The method of claim 43, wherein the change indicates a spectral shift and each optical response includes at least one spectral resonance feature with a full-width at half-maxima (FWHM) that is smaller than the spectral shift.

46. The method of claim 41, wherein the at least one optical sensor are coupled to one or more optical waveguides configured to propagate the plurality of optical signals to one or more optical detectors.

47. The method of claim 41, wherein the at least one optical sensor has a bandwidth covering a frequency range between the subharmonic frequency and the superharmonic frequency.

48. The method of claim 41, wherein the at least one optical sensor comprise a closed loop of a material that is optically transparent to the one or more optical responses.

49. The method of claim 41, wherein the at least one optical sensor is configured to have an effective refractive index and a wall thickness that enable propagation of a set of whispering gallery modes (WGMs) in the at least one optical sensor.

50. The method of claim 49, wherein the at least one optical sensor is embedded in a polymer structure with an effective refractive index lower than the effective refractive index of the at least one optical sensor.

51. The method of claim 49, wherein the effective refractive index of the at least one optical sensor changes due to a photo-elastic effect upon receipt of the plurality of ultrasound echoes.

52. The method of claim 41, wherein the medium is a non-linear medium.

53. The method of claim 41, wherein the medium is a biological tissue.