CLAIMS

1. A method of acousto-optic imaging comprising:

receiving a first signal from a first sub-aperture of a sensor array, wherein the first sub aperture comprises one or more array elements of a first type;

receiving a second signal from a second sub-aperture of the sensor array, wherein the second sub-aperture comprises one or more array elements of a second type different from the first type, wherein the second type is an optical sensor; and

combining the first signal and the second signal to form a synthesized aperture for the sensor array.

2. The method of claim 1, further comprising:

phase matching the first signal and the second signal.

3. The method of claim 2, wherein phase matching the first signal and the second signal comprising applying a first delay to the first signal or a second delay to the second signal, the first delay and the second delay being determined based at least in part on a difference between a first propagation time from the one or more array elements of a first type to a medium being imaged and a second propagation time from the one or more array elements of a second type to the medium.

4. The method of claim 3, wherein the first delay or the second delay is determined based at least in part on a thickness and acoustic velocity of an acoustic lens, ~~or~~ a thickness and acoustic velocity of an acoustic matching layer, a transmit and/or receive foci, or a thickness and acoustic velocity of each of an acoustic lens and an acoustic matching layer.

~~5. The method of claim 3, wherein the first delay or the second delay is based at least in part on transmit and/or receive foci.~~

5~~6~~. The method of claim 1, further comprising:

filtering the first signal to reduce noise in the first signal and filtering the second signal to reduce noise in the second signal.

6~~7~~. The method of claim 1, further comprising:

amplifying the first signal or the second signal by an amplification gain to amplitude match the first signal and the second signal.

~~8. The method of claim 7, wherein the amplification gain is a preset value.~~

~~9. The method of claim 7, wherein the amplification gain is determined based at least in part on imaging depth.~~

~~10. The method of claim 1, further comprising:~~

~~frequency matching the first signal and the second signal.~~

7~~11~~. The method of claim 1~~2~~, wherein the first signal is a combination of signals originating from a plurality of array elements of the first type or the second signal is a combination of signals originating from a plurality of array elements of the second type, or both.

8~~12~~. The method of claim 7~~11~~, further comprising one or more of the following, before phase matching the first signal and the second signal:

generating the first signal by combining signals originating from a plurality of array elements of the first type, or a plurality of array elements of the first type and the second type; and

generating the second signal by combining signals originating from a plurality of array elements of the second type, or a plurality of array elements of the first type and the second type.

913. The method of claim 812, further comprising forming a larger effective array element from a plurality of array elements of the first type, the second type, or both the first and second types.

~~14. The method of claim 12, further comprising reducing an effective number of array elements in the synthesized aperture.~~

1015. The method of claim 812, further comprising reducing the effective dimensionality of the synthesized aperture.

~~16. The method of claim 15, wherein the sensor array is a 1.5 dimensional (1.5D) array, and wherein the method comprises reducing an effective dimensionality of the synthesized aperture from 1.5D to 1 dimensional (1D).~~

~~17. The method of claim 15, wherein the sensor array is a 2 dimensional (2D) array, and wherein the method comprises reducing an effective dimensionality of the synthesized aperture from 2D to 1.5 dimensional (1.5D).~~

1118. The method of claim 1, further comprising:

frequency matching the first signal and the second signal; and/or

~~after frequency matching the first signal and the second signal,~~ amplitude matching the first signal and the second signal; and/or

~~after frequency matching and amplitude matching the first signal and the second signal,~~ phase matching the first signal and the second signal.

~~19. The method of claim 1, further comprising:~~

~~phase matching the first signal and the second signal;~~

~~after phase matching the first signal and the second signal, amplitude matching the first signal and the second signal; and~~

~~after phase matching and amplitude matching the first signal and the second signal, frequency matching the first signal and the second signal.~~

1220. The method of claim 1, wherein the combination of the first signal and the second signal is a coherent combination.

~~21. The method of claim 1, wherein the optical sensor is an optical resonator.~~

~~22. The method of claim 21, wherein the optical resonator is a whispering gallery mode (WGM) optical resonator.~~

~~23. The method of claim 21, wherein the optical resonator is a microbubble optical resonator, a photonic integrated circuit (PIC) optical resonator, a microsphere resonator, a micro-toroid resonator, micro-ring resonator, or a micro-disk optical resonator.~~

~~24. The method of claim 1, wherein the one or more array elements of the first type include a piezoelectric transducer, a single crystal material transducer, a piezoelectric micromachined ultrasound transducer (PMUT), or a capacitive micromachined ultrasonic transducer (CMUT) .~~

1325. The method of claim 1, further comprising:

selecting the first sub-aperture for transmitting acoustic signals; and

selecting the first sub-aperture or the second sub-aperture for receiving acoustic echoes in response to the acoustic signals.

~~26. The method of claim 1, further comprising:~~

~~selecting an element from the one or more array elements of the first type for transmitting acoustic signals; and~~

~~selecting the first aperture or the second sub-aperture for receiving acoustic echoes in response to the acoustic signals.~~

~~27. The method of claim 1, further comprising:~~

~~selecting an angle for transmitting acoustic signals;~~

~~transmitting the acoustic signals; and~~

~~receiving acoustic echoes in response to the acoustic signals.~~

~~28. The method of claim 1, wherein the optical sensor is embedded in a polymer structure.~~

14~~29~~. An apparatus for imaging a target, comprising:

one or more array elements of a first type forming a first sub-aperture;

one or more array elements of a second type different from the first type and forming a second sub-aperture, the second type being an optical sensor, wherein the first sub-aperture receives a first signal having a first phase and the second sub-aperture receives a second signal having a second phase; and

a front-end configured to generate a synthesized aperture at least in part by combining the first signal and the second signal.

15~~30~~. The apparatus of claim 14~~29~~, the front-end is further configured to generate the synthesized aperture by phase matching the first signal and the second signal.

16~~31~~. The apparatus of claim 15~~30~~, wherein phase matching the first signal and the second signal comprise applying a first delay to the first signal or a second delay to the second signal, the first delay and the second delay being determined based at least in part on a difference between a first propagation time from the one or more array elements of a first type to a medium being imaged and a second propagation time from the one or more array elements of a second type to the medium.

17~~32~~. The apparatus of claim 16~~31~~, wherein the first delay or the second delay is determined based at least in part on a thickness and acoustic velocity of an acoustic lens, or a thickness and acoustic velocity of an acoustic matching layer, or on transmit and receive foci, or a thickness and acoustic velocity of each of an acoustic lens and an acoustic matching layer.

~~33. The apparatus of claim 31, wherein the first delay or the second delay is based at least in part on transmit and receive foci.~~

1834. The apparatus of claim 1429, wherein the front-end is further configured to generate the synthesized aperture by filtering the first signal to reduce noise in the first signal and filtering the second signal to reduce noise in the second signal.

1935. The apparatus of claim 1429, wherein the front-end is further configured to generate the synthesized aperture by amplifying the first signal or the second signal by an amplification gain to amplitude match the first signal and the second signal.

~~36. The apparatus of claim 35, wherein the amplification gain is a preset value.~~

~~37. The apparatus of claim 35, wherein the amplification gain is determined based at least in part on imaging depth.~~

2038. The apparatus of claim 1429, wherein the front-end is further configured to generate the synthesized aperture by frequency matching the first signal and the second signal.

2139. The apparatus of claim 1429, wherein the first signal is a combination of signals originating from a plurality of array elements of the first type or the second signal is a combination of signals originating from a plurality of array elements of the second type.

2240. The apparatus of claim 1429, wherein the front-end is further configured to generate the synthesized aperture by:

frequency matching the first signal and the second signal; and/or

~~after frequency matching the first signal and the second signal,~~ amplitude matching the first signal and the second signal; and/or

~~after frequency matching and amplitude matching the first signal and the second signal,~~ phase matching the first signal and the second signal.

~~41. The apparatus of claim 29, wherein the front-end is further configured to generate the synthesized aperture by:~~

~~phase matching the first signal and the second signal;~~

~~after phase matching the first signal and the second signal, amplitude matching the first signal and the second signal; and~~

~~after phase matching and amplitude matching the first signal and the second signal, frequency matching the first signal and the second signal.~~

2342. The apparatus of claim 1429, wherein the combination of the first signal and the second signal is a coherent combination.

~~43. The apparatus of claim 29, wherein the optical sensor is an optical resonator.~~

~~44. The apparatus of claim 43, wherein the optical resonator is whispering gallery mode (WGM) optical resonator.~~

~~45. The apparatus of claim 43, wherein the optical resonator is a microbubble optical resonator, a photonic integrated circuit (PIC) optical resonator, a microsphere resonator, a micro-toroid resonator, micro-ring resonators, or a micro-disk optical resonator.~~

~~46. The apparatus of claim 43, wherein the one or more array elements of the first type include a piezoelectric transducer, single crystal material transducer, a piezoelectric micromachined ultrasound transducer (PMUT), or a capacitive micromachined ultrasonic transducer (CMUT).~~

2447. The apparatus of claim 1429, wherein the front-end is further configured to combine the first signal and the second signal by:

selecting the first sub-aperture for transmitting acoustic signals; and

selecting the first sub-aperture or the second sub-aperture for receiving acoustic echoes in response to the acoustic signals.

2548. The apparatus of claim 1429, wherein the front-end is further configured to combine the first signal and the second signal by:

selecting an element from the one or more array elements of the first type for transmitting acoustic signals; and

selecting the first aperture or the second sub-aperture for receiving acoustic echoes in response to the acoustic signals.

~~49. The apparatus of claim 29, wherein the front-end is further configured to combine the first signal and the second signal by:~~

~~selecting an angle for transmitting acoustic signals;~~

~~transmitting the acoustic signals; and~~

~~receiving acoustic echoes in response to the acoustic signals.~~

~~50. The apparatus of claim 29, wherein the one or more array elements of the first type and the one or more array elements of the second type comprises one or more rows in an elevation dimension.~~

~~51. The apparatus of claim 50, wherein the one or more array elements of the first type and the one or more array elements of the second type comprises at least one row comprising at least one array element of the first type and at least one array element of the second type.~~

~~52. The apparatus of claim 29, the one or more array elements of the first type and the one or more array elements of the second type are in a 1 dimensional (1D) array.~~

~~53. The apparatus of claim 29, the one or more array elements of the first type and the one or more array elements of the second type are in a 1.25 dimensional (1.25D) array.~~

~~54. The apparatus of claim 53, wherein the one or more array elements of the first type and the one or more array elements of the second type are arranged in an array, wherein~~

~~the array comprises a first row having a first number of array elements and a second row having a second number of array elements.~~

~~55. The apparatus of claim 54, wherein the first number of array elements in the first row is equal to the second number of array elements in the second row.~~

~~56. The apparatus of claim 54, wherein the first number of array elements in the first row is different from the second number of array elements in the second row.~~

~~57. The apparatus of claim 29, the one or more array elements of the first type and the one or more array elements of the second type are in a 1.5 dimensional (1.5D) array.~~

~~58. The apparatus of claim 57, wherein the one or more array elements of the first type and the one or more array elements of the second type are arranged in an array, wherein the array comprises a first row having a first number of array elements and a second row having a second number of array elements.~~

~~59. The apparatus of claim 58, wherein the first number of array elements in the first row is equal to the second number of array elements in the second row.~~

~~60. The apparatus of claim 58, wherein the first number of array elements in the first row is different from the second number of array elements in the second row.~~

~~61. The apparatus of claim 29, the one or more array elements of the first type and the one or more array elements of the second type are in a 1.75 dimensional (1.75D) array.~~

~~62. The apparatus of claim 29, the one or more array elements of the first type and the one or more array elements of the second type are in a 2 dimensional (2D) array.~~

~~63. The apparatus of claim 29, wherein the one or more array elements of the second type include one or more optical sensors embedded in a polymer structure.~~

~~64. The apparatus of claim 29, wherein the optical sensor is optically coupled to an optical fiber to transmit a set of optical signals to a photodetector.~~