

CLAIMS

What is claimed is:

1. An acoustic sensor, comprising:
 - an optical whispering gallery mode resonator;
 - a coupling waveguide for optically coupling to the resonator, the coupling waveguide being spaced from the resonator by a separation gap; and
 - a polymer encasing a portion of the coupling waveguide and the resonator;wherein the resonator and the coupling waveguide each have higher refractive indices than the corresponding refractive index of the polymer.
2. The acoustic sensor of claim 1, wherein the separation gap is selected such that the acoustic sensor operates at an operating condition selected from critical coupling of the resonator and the coupling waveguide or at a maximum loading factor.
3. The acoustic sensor of claim 1, wherein the resonator comprises a diameter ranging from about 50 μm to about 200 μm .
4. The acoustic sensor of claim 1, wherein the separation gap ranges from about 0.6 μm to about 0.8 μm .
5. The acoustic sensor of claim 1, wherein the separation gap results in a maximum loading factor during operation of the acoustic sensor.
6. The acoustic sensor of claim 1, wherein the coupling waveguide is a tapered optic fiber with a minimum taper diameter of less than about 1.5 μm .
7. The acoustic sensor of claim 1, wherein the acoustic sensor encodes pressure fluctuations as fluctuations in a transmission amplitude through the resonator.
8. The acoustic sensor of claim 1, wherein the polymer is a UV-curable polymer with an refractive index of 1.33
9. An acoustic sensing system, comprising:
 - an optical whispering gallery mode resonator;
 - a coupling waveguide for optically coupling to the resonator, the coupling waveguide having a first end and a second end opposite the first end, the coupling waveguide being spaced from the resonator by a separation gap; and

- a polymer encasing the resonator and a portion of the coupling waveguide;
 - a light source coupled to the first end of the coupling waveguide projecting from the low-index polymer; and
 - a light detector coupled to the second end of the coupling waveguide and projecting from the low-index polymer;
- wherein the resonator and the coupling waveguide each have higher refractive indices than the corresponding refractive index of the polymer.
10. The acoustic sensing system of claim 9, further comprising a driving system having a computing device with a processor, the driving system being operatively coupled to the light source and the light detector, wherein the driving system is configured to:
- obtain a transmission spectrum by operating the light source at a range of wavelengths and receiving a plurality of detector signals from the light detector, the detector signals encoding the transmission of light from the light source through the coupling fiber coupled to the resonator;
 - select an operating wavelength for detecting pressure fluctuations based on the transmission spectrum; and
 - select the separation gap based on at least one transmission spectrum; and
 - detect pressure fluctuations by operating the light source at the operating wavelength and receiving a second plurality of signals from the light detector.
11. The acoustic sensing system of claim 10, wherein the acoustic sensor encodes pressure fluctuations as fluctuations in transmission amplitude wave optical whispering gallery mode resonator.
12. An ultrasound imaging device, comprising:
- an acoustic sensor comprising:
 - an optical whispering gallery mode resonator;
 - a coupling waveguide for optically coupling to the resonator, the coupling waveguide having a first end and a second end opposite

the first end, the coupling waveguide being spaced from the resonator by a separation gap;

a polymer encasing the resonator and a portion of the coupling waveguide;

a light source coupled to the first end of the coupling waveguide projecting from the low-index polymer; and

a light detector coupled to the second end of the coupling waveguide opposite to the first end and projecting from the low-index polymer;

wherein the resonator and the coupling waveguide each have higher refractive indices than the corresponding refractive index of the polymer.

13. The ultrasound imaging device of claim 12, wherein the acoustic sensor encodes pressure fluctuations as fluctuations in a transmission amplitude through the resonator.
14. The ultrasound imaging device of claim 12, wherein the acoustic sensor is configured to detect ultrasound pulses generated within a region of interest in response to excitatory ultrasound pulses directed into the region of interest by an ultrasound transducer.
15. A photoacoustic imaging device, comprising:
 - an acoustic sensor comprising:
 - an optical whispering gallery mode resonator;
 - a coupling waveguide for optically coupling to the resonator, the coupling waveguide having a first end and a second end opposite the first end, the coupling waveguide being spaced from the resonator by a separation gap;
 - a polymer encasing the resonator and a portion of the coupling waveguide;
 - a transducer light source coupled to the first end of the coupling

waveguide projecting from the low-index polymer;

a transducer light detector coupled to the second end of the coupling waveguide opposite to the first end and projecting from the low-index polymer; and

a photoacoustic light source;

wherein the resonator and the coupling waveguide each have higher refractive indices than the corresponding refractive index of the polymer.

16. The ultrasound imaging device of claim 15, wherein the acoustic sensor encodes pressure fluctuations as fluctuations in a transmission amplitude through the resonator.
17. The ultrasound imaging device of claim 15, wherein the acoustic sensor is configured to detect photoacoustic signals generated within a region of interest in response to illumination by laser pulses produced by the photoacoustic light source.
18. A method for detecting ultrasound waves, the method comprising:
 - providing an acoustic sensing system, comprising:
 - an optical whispering gallery mode resonator;
 - a coupling waveguide for optically coupling to the resonator, the coupling waveguide having a first end and a second end opposite the first end, the coupling waveguide being spaced from the resonator by a separation gap; and
 - a polymer encasing the resonator and a portion of the coupling waveguide, the polymer further forming a sample contact surface;
 - a light source for coupling to the first end of the coupling waveguide projecting from the low-index polymer; and
 - a light detector for coupling to the second end of the coupling waveguide and projecting from the low-index polymer;
 - wherein the resonator and the coupling waveguide each have higher

refractive indices than the corresponding refractive index of the polymer;

acoustically coupling the sample contact surface with a sample such that ultrasound waves emitting from within the sample are conducted through the polymer to the resonator and the portion of the coupling waveguide;

introducing light produced by the light source into the first end of the coupling waveguide;

converting light from the second end of the coupling waveguide detected by the light detector into detector signals encoding the amplitude of the detected light; and

transforming the detector signals into a pressure using a predetermined calibration rule.