CLAIMS

1. An apparatus comprising:

a display;

an ultrasonic sensor system underlying the display and configured to transmit and receive ultrasonic waves in an acoustic path through the display;

a light-blocking layer between the ultrasonic sensor system and the display, the light-blocking layer positioned in the acoustic path; and

an adhesive layer between the display and the ultrasonic sensor system, the adhesive layer positioned in the acoustic path and configured to allow the ultrasonic sensor system to be separated from the display.

2. The apparatus of claim 1, further comprising:

an electrical shielding layer between the ultrasonic sensor system and the display, the electrical shielding layer being electrically conductive and grounded, the electrical shielding layer positioned in the acoustic path.

3. The apparatus of claim 2, wherein each of the electrical shielding layer and the light-blocking layer is non-porous or substantially non-porous.

4. The apparatus of claim 2, wherein the light-blocking layer includes an opaque plastic material and the electrical shielding layer includes a metal or metalized plastic having a thickness between about 0.1 μm and about 9 μm.

5. The apparatus of claim 1, wherein the display is an organic light-emitting diode (OLED) display.

6. The apparatus of claim 5, wherein the display is a flexible OLED display formed on a plastic substrate.

7. The apparatus of any one of claims 1-6, wherein the adhesive layer includes a pressure-sensitive adhesive.

8. The apparatus of any one of claims 1-6, wherein the adhesive layer includes an epoxy-based adhesive, the epoxy-based adhesive including a thermoplastic ink.

9. The apparatus of any one of claims 1-6, further comprising:

a mechanical stress isolation layer between the adhesive layer and the ultrasonic sensor system, wherein the mechanical stress isolation layer includes a plastic material.

10. The apparatus of any one of claims 1-6, wherein the ultrasonic sensor system includes:

a sensor substrate having a plurality of sensor pixel circuits disposed thereon;

a piezoelectric transceiver layer coupled to the sensor substrate and including a piezoelectric material configured to generate the ultrasonic waves; and

an electrode layer coupled to the piezoelectric transceiver layer.

11. The apparatus of claim 10, wherein the piezoelectric transceiver layer is underlying the sensor substrate and the electrode layer is underlying the piezoelectric transceiver layer.

12. The apparatus of claim 10, wherein the piezoelectric transceiver layer is underlying the electrode layer and the sensor substrate is underlying the piezoelectric transceiver layer.

13. The apparatus of claim 10, wherein the piezoelectric transceiver layer includes polyvinylidene fluoride (PVDF), polyvinylidene fluoride trifluoroethylene (PVDF-TrFE) copolymer, lead zirconate titanate (PZT), aluminum nitride (AlN), or composites thereof.

14. The apparatus of claim 10, wherein the sensor substrate comprises a material selected from the group consisting of: glass, plastic, silicon, and stainless steel.

15. An apparatus comprising:

a display;

an ultrasonic sensor system underlying the display and configured to transmit and receiving ultrasonic waves in an acoustic path through the display; and

an adhesive layer between the ultrasonic sensor system and the display, the adhesive layer positioned in the acoustic path.

16. The apparatus of claim 15, further comprising:

a mechanical stress isolation layer between the adhesive layer and the ultrasonic sensor system, the mechanical stress isolation layer including a plastic material and positioned in the acoustic path.

17. The apparatus of claim 15, wherein the ultrasonic sensor system spans across an entirety or substantial entirety of an active area of the display.

18. The apparatus of claim 15, wherein the display is an organic light-emitting diode (OLED) display.

19. The apparatus of any one of claims 15-18, wherein the adhesive layer is reworkable and configured to allow the ultrasonic sensor system to be separated from the display, the adhesive layer including a pressure-sensitive adhesive or an epoxy-based adhesive.

20. The apparatus of any one of claims 15-18, further comprising:

a light-blocking layer between the adhesive layer and the display, the light-blocking layer positioned in the acoustic path; and

an electrical shielding layer between the adhesive layer and the display, the electrical shielding layer being electrically conductive and grounded, the electrical shielding layer positioned in the acoustic path, wherein each of the light-blocking layer and the electrical shielding layer is non-porous or substantially non-porous.

21. An apparatus comprising:

a display;

an ultrasonic sensor system underlying the display and configured to transmit and receiving ultrasonic waves in an acoustic path through the display; and

a multi-functional film between the ultrasonic sensor system and the display, wherein the multi-functional film includes a light-blocking layer, an electrical shielding layer, an adhesive layer, a mechanical stress isolation layer, or combinations thereof, the multi-functional film positioned in the acoustic path.

22. A method of manufacturing an apparatus, the method comprising:

providing a display device, wherein the display device includes a platen and a display underlying the platen;

bonding a light-blocking layer, an electrical shielding layer, a mechanical stress isolation layer, or combinations thereof to the display, wherein the electrically shielding layer is electrically conductive and grounded; and

bonding an ultrasonic sensor system to the light-blocking layer, the electrical shielding layer, the mechanical stress isolation layer, or combinations thereof, wherein the ultrasonic sensor system is underlying the display and configured to transmit and receive ultrasonic waves in an acoustic path through the display and the platen, wherein the light-blocking layer, the electrical shielding layer, the mechanical stress isolation layer, or combinations thereof are in the acoustic path.

23. The method of claim 22, wherein bonding the light-blocking layer, the electrical shielding layer, the mechanical stress isolation layer, or combinations thereof include laminating the light-blocking layer, the electrical shielding layer, the mechanical stress isolation layer, or combinations thereof to the display.

24. The method of claim 22, further comprising:

bonding an adhesive layer to the display to allow at least the ultrasonic sensor system to be separated from the display, wherein the adhesive layer is positioned in the acoustic path.

25. An apparatus comprising:

a display;

an ultrasonic sensor system underlying the display and configured to transmit and receive ultrasonic waves in an acoustic path through the display, wherein the ultrasonic sensor system comprises:

~~a flexible substrate including a plurality of sensor pixel circuits disposed thereon; and~~

~~a piezoelectric transceiver layer coupled to the flexible substrate and including a piezoelectric material configured to generate the ultrasonic waves; and~~

~~a first high acoustic impedance layer between the piezoelectric transceiver layer and the display.~~

~~26. The apparatus of claim 25, wherein the first high acoustic impedance layer includes a one or both of a light-blocking layer and an electrical shielding layer.~~

~~27. The apparatus of claim 25, wherein the first high acoustic impedance layer includes an electrode layer adjacent to the piezoelectric transceiver layer.~~

~~28. The apparatus of any one of claims 25-27, wherein the high acoustic impedance value layer has an acoustic impedance value greater than about 5.0 MRayls.~~

~~29. The apparatus of any one of claims 25-27, further comprising:~~

~~an adhesive layer between the display and the ultrasonic sensor system, the adhesive layer positioned in the acoustic path and configured to allow the ultrasonic sensor system to be separated from the display.~~

~~30. The apparatus of any one of claims 25-27, wherein the flexible substrate includes polyethylene terephthalate (PET), polyethylene naphthalate (PEN), a polyimide, stainless steel foil, thin film silicon, or other flexible material.~~

~~31. The apparatus of any one of claims 25-27, further comprising:~~

~~a second high acoustic impedance layer on a back side of the ultrasonic sensor system.~~

1. An invention not claimed in any divisional application.