

CLAIMS

1. ~~1. An electronic filter comprising:
a piezoelectric substrate having a top surface, a bottom surface, and a side surface;
a filter circuit including a plurality of surface acoustic wave (SAW) resonators formed on the top surface of the piezoelectric substrate;
a sealing substrate having a top surface and a bottom surface; and
an electrically conductive side wall formed to define a cavity between the top surface of the piezoelectric substrate and the bottom surface of the sealing substrate, the side wall enclosing a periphery of the filter circuit and being connected to a ground potential of the filter circuit.~~
2. ~~2. The electronic filter of claim 1 wherein the filter circuit includes a first signal pad corresponding to an input and a second signal pad corresponding to an output.~~
3. ~~3. The electronic filter of claim 2 wherein the plurality of resonators form a ladder type filter including a plurality of series resonators connected in series between the first signal pad and the second signal pad and a plurality of parallel resonators connected in parallel between the plurality of series resonators and the ground potential.~~
4. ~~4. The electronic filter of claim 3 wherein the side wall includes a protrusion projecting toward the filter circuit.~~

5. ~~The electronic filter of claim 4 wherein the protrusion forms a partition wall between one of the plurality of series resonators and one of the plurality of parallel resonators.~~

6. ~~The electronic filter of claim 3 wherein the filter circuit further includes a plurality of ground pads connected to the plurality of parallel resonators.~~

7. ~~The electronic filter of claim 6 further comprising:~~

~~a plurality of external signal electrode pads disposed on the top surface of the sealing substrate, each of the plurality of external signal electrode pads being connected to one of the first signal pad and a second signal pad via a first columnar electrode; and~~

~~a plurality of external ground electrode pads disposed on the top surface of the sealing substrate, each of the plurality of external ground electrode pads being connected to each of the plurality of ground pads via a second columnar electrode.~~

8. ~~The electronic filter of claim 7 further comprising a partition wall disposed between the second columnar electrode and the side wall.~~

9. ~~The electronic filter of claim 6 wherein the filter circuit further includes an additional ground pad that is connected to the side wall and not connected to any of the plurality of resonators.~~

~~10. — The electronic filter of claim 6 wherein at least one of the plurality of ground pads is connected to the side wall.~~

~~11. — The electronic filter of claim 10 further comprising a wiring layer disposed on the bottom surface of the sealing substrate, the side wall extending between the top surface of the piezoelectric substrate and the wiring layer.~~

~~12. — The electronic filter of claim 11 further comprising a plurality of electrode pads disposed on the top surface of the sealing substrate and connected to the plurality of ground pads via a plurality of columnar electrodes, at least two of the columnar electrodes being connected to each other by the wiring layer.~~

~~13. — The electronic filter of claim 11 further comprising an external ground electrode pad disposed on the top surface of the sealing substrate and connected to the wiring layer.~~

~~14. — The electronic filter of claim 13 wherein the wiring layer includes an additional circuit including at least one of an inductor and a capacitor.~~

~~15. — The electronic filter of claim 14 wherein the additional circuit includes the inductor, the inductor being formed by a lead wire having a spiral shape or a meandering shape.~~

16. ~~—The electronic filter of claim 15 wherein the additional circuit includes the capacitor, the capacitor being formed by lead wires positioned opposing one other.~~

17. ~~—The electronic filter of claim 1 further comprising a conductive shielding layer disposed on the top surface of the piezoelectric substrate to cover at least one of the plurality of resonators.~~

18. ~~—The electronic filter of claim 1 further comprising a conductive shielding layer disposed to cover the side surface of the piezoelectric substrate and the side wall.~~

19. ~~—The electronic filter of claim 18 wherein the conductive shielding layer is further disposed to cover the bottom surface of the piezoelectric substrate.~~

20. ~~—A filter module comprising the electronic filter of any of claims 1-19.~~

21. ~~—A wireless device comprising:~~

~~—an antenna;~~

~~—a transceiver configured to produce a transmit signal for transmission by the antenna and to process a received signal from the antenna;~~

~~—an antenna switch module coupled between the antenna and the transceiver and configured to selectively configure the wireless device between a receive mode and a transmit mode; and~~

~~the filter module of claim 20 coupled between the antenna switch module and the transceiver, the filter module being configured to filter at least one of the transmit signal and the received signal.~~

22. ~~A filter device comprising:~~

~~a piezoelectric substrate having a top surface;~~

~~a pair of filter circuits formed on the top surface of the piezoelectric substrate and including a plurality of resonators;~~

~~a sealing substrate having a bottom surface; and~~

~~an electrically conductive side wall disposed to define a cavity between the top surface of the piezoelectric substrate and the bottom surface of the sealing substrate, the side wall enclosing a periphery of the pair filter circuits and being electrically connected to a ground potential of the pair filter circuits.~~

23. ~~The filter device of claim 22 wherein the pair of filter circuits includes a first filter circuit and a second filter circuit, and wherein the side wall includes a protrusion projecting toward a connection between the first and second filter circuits, the protrusion forming a partition wall between the first and second filter circuits.~~

Claims

1. An electronic filter comprising:

a piezoelectric substrate having a top surface, a bottom surface, and a side surface;

a filter circuit including a plurality of surface acoustic wave (SAW) resonators formed on the top surface of the piezoelectric substrate;

a sealing substrate having a top surface and a bottom surface;

an electrically conductive side wall formed to define a cavity between the top surface of the piezoelectric substrate and the bottom surface of the sealing substrate, the side wall enclosing a periphery of the filter circuit and being connected to a ground potential of the filter circuit; and

a conductive shielding layer disposed to cover the side surface of the piezoelectric substrate, the bottom surface of the piezoelectric substrate, and the side wall.

2. An electronic filter comprising:

a piezoelectric substrate having a top surface, a bottom surface, and a side surface;

a filter circuit including a plurality of surface acoustic wave (SAW) resonators formed on the top surface of the piezoelectric substrate;

a sealing substrate having a top surface and a bottom surface;

an electrically conductive side wall formed to define a cavity between the top surface of the piezoelectric substrate and the bottom surface of the sealing substrate, the side wall enclosing a periphery of the filter circuit and being connected to a ground potential of the filter circuit; and

a ground pad that is connected to the side wall and not connected to any of the plurality of resonators.

3. The electronic filter of claim 2 further comprising a conductive shielding layer disposed on the top surface of the piezoelectric substrate to cover at least one of the plurality of resonators.

4. The electronic filter of claim 2 wherein the filter circuit includes a first signal pad corresponding to an input of the filter circuit and a second signal pad corresponding to an output of the filter circuit.

5. The electronic filter of claim 4 wherein the plurality of resonators form a ladder-type filter including a plurality of series resonators connected in series between the first signal pad and the second signal pad and a plurality of parallel resonators connected in parallel between the plurality of series resonators and the ground potential.

6. The electronic filter of claim 5 wherein the filter circuit further includes a plurality of ground pads connected to the plurality of parallel resonators.

7. The electronic filter of claim 6 further comprising:

a plurality of external signal electrode pads disposed on the top surface of the sealing substrate, each of the plurality of external signal electrode pads being connected to one of the first signal pad and a second signal pad via a respective first columnar electrode; and

a plurality of external ground electrode pads disposed on the top surface of the sealing substrate, each of the plurality of external ground electrode pads being connected to each of the plurality of ground pads via a respective second columnar electrode.

8. The electronic filter of claim 7 further comprising a partition wall disposed between each respective second columnar electrode and the side wall.

9. The electronic filter of claim 5 wherein the side wall includes a protrusion projecting toward the filter circuit.

10. The electronic filter of claim 9 wherein the protrusion forms a partition wall between one of the plurality of series resonators and one of the plurality of parallel resonators.

11. The electronic filter of claim 6 wherein at least one of the plurality of ground pads is connected to the side wall.

12. The electronic filter of claim 11 further comprising a wiring layer disposed on the bottom surface of the sealing substrate, the side wall extending between the top surface of the piezoelectric substrate and the wiring layer.

13. The electronic filter of claim 12 further comprising an external ground electrode pad disposed on the top surface of the sealing substrate and connected to the wiring layer.

14. The electronic filter of claim 13 wherein the wiring layer includes an additional circuit including at least one of an inductor and a capacitor.

15. The electronic filter of claim 14 wherein the additional circuit includes the inductor, the inductor being formed by a lead wire having a spiral shape or a meandering shape.

16. The electronic filter of claim 15 wherein the additional circuit includes the capacitor, the capacitor being formed by lead wires positioned opposing one other.

17. The electronic filter of claim 12 further comprising a plurality of electrode pads disposed on the top surface of the sealing substrate and connected to the plurality of ground pads via a respective one of a plurality of columnar electrodes, at least two columnar electrodes of the plurality of columnar electrodes being connected to each other by the wiring layer.

18. The electronic filter of claim 2 further comprising a conductive shielding layer disposed to cover the side surface of the piezoelectric substrate and the side wall.

19. The electronic filter of claim 18 wherein the conductive shielding layer is further disposed to cover the bottom surface of the piezoelectric substrate.

20. A filter device comprising:

a piezoelectric substrate having a top surface, a bottom surface, and a side surface;

a pair of filter circuits formed on the top surface of the piezoelectric substrate and including a plurality of resonators;

a sealing substrate having a bottom surface;

an electrically conductive side wall disposed to define a cavity between the top surface of the piezoelectric substrate and the bottom surface of the sealing substrate, the side wall enclosing a periphery of the pair of filter circuits and being electrically connected to a ground potential of the pair of filter circuits; and

a conductive shielding layer disposed to cover the side surface of the piezoelectric substrate, the bottom surface of the piezoelectric substrate, and the side wall.

21. The filter device of claim 20 wherein the pair of filter circuits includes a first filter circuit and a second filter circuit, and wherein the side wall includes a protrusion projecting toward a connection between the first and second filter circuits, the protrusion forming a partition wall between the first and second filter circuits.

22. An electronic filter comprising:

a piezoelectric substrate having a top surface, a bottom surface, and a side surface;

a filter circuit including a plurality of surface acoustic wave (SAW) resonators formed on the top surface of the piezoelectric substrate;

a sealing substrate having a top surface and a bottom surface;

an electrically conductive side wall formed to define a cavity between the top surface of the piezoelectric substrate and the bottom surface of the sealing substrate, the side wall enclosing a periphery of the filter circuit and being connected to a ground potential of the filter circuit; and

a wiring layer disposed on the bottom surface of the sealing substrate, the side wall extending between the top surface of the piezoelectric substrate and the wiring layer, the wiring layer including an additional circuit having at least one of an inductor and a capacitor.