Claims

What is claimed:

1. A semiconductor device for a radio frequency front end module (RF FEM), comprising:

a substrate including a semiconductor material;

an inductor capacitor (LC) filter disposed over the substrate and including an input coupled for receiving a transmit signal of the RF FEM and an output for providing a filtered transmit signal; and

an integrated passive device (IPD) filter disposed over the substrate and including an input coupled for receiving a receive signal of the RF FEM and an output for providing a filtered receive signal , wherein the IPD filter comprises,

a first conductive trace wound to exhibit an inductive property and including first and second ends of the first conductive trace coupled to the input of the IPD filter,

a second conductive trace disposed in proximity to the first conductive trace to exhibit a mutual inductive property and including first and second ends of the second conductive trace coupled to the output of the IPD filter, and

a third conductive trace disposed around a perimeter of the first conductive trace and second conductive trace.

2. The semiconductor device of claim 1, further including:

a transmit/receive (Tx/Rx) switch disposed over the substrate and including a first terminal coupled to the output of the LC filter and a second terminal coupled to the input of the IPD filter; and

a diplexer disposed over the substrate and including a first terminal coupled to a third terminal of the Tx/Rx switch and a second terminal for providing an RF signal.

3. The semiconductor device of claim 1, wherein the IPD filter further includes:

a first capacitor coupled between the first and second ends of the first conductive trace;

a second capacitor coupled between the first and second ends of the second conductive trace; and

a third capacitor coupled between the first and second ends of the third conductive trace.

4. The semiconductor device of claim 1, wherein the LC filter includes:

a third conductive trace wound to exhibit an inductive property and including first and second ends coupled to the input of the LC filter; and

a fourth conductive trace wound to exhibit an inductive property and including first and second ends coupled to the output of the LC filter, the fourth conductive trace being disposed in proximity to the third conductive trace to exhibit a mutual inductive property.

5. The semiconductor device of claim 4, wherein the LC filter further includes:

a first capacitor coupled between the first and second ends of the third conductive trace; and

a second capacitor coupled between the first and second ends of the fourth conductive trace.

6. A semiconductor device, comprising:

a substrate;

a radio frequency front end module (RF FEM) disposed over the substrate, the RF FEM including a first integrated passive device (IPD) filter for processing a transmit signal formed on the substrate and a second IPD filter for processing a receive signal formed on the substrate outside a footprint of the first IPD filter, wherein the second IPD filter includes:

a first conductive trace wound to exhibit an inductive property and including first and second ends coupled to an input of the second IPD filter;

a second conductive trace wound to exhibit an inductive property and including first and second ends coupled to an output of the second IPD filter, the second conductive trace being disposed in proximity to the first conductive trace to exhibit a mutual inductive property;

a third conductive trace wound to exhibit an inductive property and disposed in proximity to the first and second conductive traces to exhibit a mutual inductive property;

a first capacitor coupled between the first and second ends of the first conductive trace;

a second capacitor coupled between the first and second ends of the second conductive trace; and

a third capacitor coupled between the first and second ends of the third conductive trace.

7. The semiconductor device of claim 6, wherein the RF FEM further includes:

a transmit/receive (Tx/Rx) switch including a first terminal coupled to an output of the first IPD filter and a

second terminal coupled to an input of the second IPD filter; and

a diplexer including a first terminal coupled to a third terminal of the Tx/Rx switch and a second terminal for providing an RF signal.

8. The semiconductor device of claim 6, wherein the first IPD filter includes:

a first conductive trace wound to exhibit an inductive property and including first and second ends coupled to an input of the first IPD filter;

a second conductive trace wound to exhibit an inductive property and including first and second ends coupled to an output of the first IPD filter, the second conductive trace being disposed in proximity to the first conductive trace to exhibit a mutual inductive property;

a first capacitor coupled between the first and second ends of the first conductive trace; and

a second capacitor coupled between the first and second ends of the second conductive trace.

9. The semiconductor device of claim 6, further including an RF transceiver in a semiconductor package, wherein the substrate comprising the first IPD filter and second IPD filter is mounted over the semiconductor package and electrically connected to the RF transceiver.

10. A semiconductor device for a radio frequency front end module (RF FEM), comprising:

a substrate; and

an integrated passive device (IPD) filter disposed over the substrate and including an input coupled for receiving a receive signal of the RF FEM and an output for providing a filtered receive signal, wherein the IPD filter comprises,

a first conductive trace wound to exhibit an inductive property and including first and second ends of the first conductive trace coupled to the input of the IPD filter,

a second conductive trace disposed in proximity to the first conductive trace to exhibit a mutual inductive property and including first and second ends of the second conductive trace coupled to the output of the IPD filter, and

a third conductive trace disposed around a perimeter of the first conductive trace and second conductive trace.

11. The semiconductor device of claim 10, wherein the IPD filter further includes:

a first capacitor coupled between the first and second ends of the first conductive trace;

a second capacitor coupled between the first and second ends of the second conductive trace; and

a third capacitor coupled between the first and second ends of the third conductive trace.

12. The semiconductor device of claim 10, further including an LC filter disposed over the substrate outside a footprint of the IPD filter.

13. The semiconductor device of claim 12, wherein the LC filter further includes:

a third conductive trace;

a fourth conductive trace configured to exhibit mutual inductance with the third conductive trace;

a first capacitor coupled between the first and second ends of the third conductive trace; and

a second capacitor coupled between the first and second ends of the fourth conductive trace.

14. The semiconductor device of claim 10, further including an insulating layer formed over the IPD filter.

15. The semiconductor device of claim 14, further including a semiconductor package disposed on the insulating layer and including an RF component disposed in the semiconductor package.

16. The semiconductor device of claim 15, wherein the semiconductor package includes:

a transmit/receive (Tx/Rx) switch; and

a diplexer.

17. A semiconductor device for a radio frequency front end module (RF FEM), comprising:

a substrate including a semiconductor material;

an inductor capacitor (LC) filter disposed over the substrate; and

an integrated passive device (IPD) filter disposed over the substrate.

18. The semiconductor device of claim 17, wherein the IPD filter further includes:

a first conductive trace wound to exhibit an inductive property;

a second conductive trace disposed in proximity to the first conductive trace to exhibit a mutual inductive property; and

a third conductive trace disposed around a perimeter of the first conductive trace and a perimeter of the second conductive trace.

19. The semiconductor device of claim 17, further including:

an insulating layer disposed over the substrate, LC filter, and IPD filter; and

a semiconductor die including an amplifier disposed over the insulating layer.

20. The semiconductor device of claim 19, further including a bond wire coupled between the semiconductor die and substrate.

21. The semiconductor device of claim 19, wherein the insulating layer includes polyamide.

22. The semiconductor device of claim 17, wherein the substrate includes a high resistivity substrate.

23. The semiconductor device of claim 17, wherein the LC filter is disposed over the substrate outside a footprint of the IPD filter.