SUMMARY

[0005] The innovations described in the claims each have several aspects, no single one of which is solely responsible for its desirable attributes. Without limiting the scope of the claims, some prominent features of this disclosure will now be briefly described.

[0005a] In an aspect, the present disclosure refers to an acoustic wave filter component comprising: a surface acoustic wave device including a first piezoelectric layer, an interdigital transducer electrode on the first piezoelectric layer, and at least a portion of a temperature compensation layer positioned on the interdigital transducer electrode; a bulk acoustic wave resonator supported by the temperature compensation layer, the bulk acoustic wave resonator including a second piezoelectric layer and electrodes on opposing sides of the second piezoelectric layer; and an internal via extending through the temperature compensation layer, the bulk acoustic wave resonator in electrical communication with the surface acoustic wave device by way of the internal via extending through the temperature compensation layer.

[0005b] In another aspect, the present disclosure refers to an acoustic wave filter component comprising: a first piezoelectric layer; an interdigital transducer electrode over the first piezoelectric layer; a temperature compensation layer over the interdigital transducer electrode; and a bulk acoustic wave resonator supported by the temperature compensation layer, the bulk acoustic wave resonator including a second piezoelectric layer and electrodes on opposing sides of the second piezoelectric layer, the bulk acoustic wave resonator is electrically connected to the interdigital transducer electrode by way of an internal via extending through the temperature compensation layer.

[0005c] In one example, the present disclosure refers to an acoustic wave filter component comprising: a multi-layer piezoelectric substrate acoustic wave device including a support substrate, a first piezoelectric layer on the support substrate, and an interdigital transducer electrode on the first piezoelectric layer; and a bulk acoustic wave resonator supported by a layer over the interdigital transducer electrode, the bulk acoustic wave resonator including a second piezoelectric layer and electrodes on opposing sides of the second piezoelectric layer.

[0005d] In one example, the present disclosure refers to an acoustic wave filter component comprising: a boundary wave resonator supported by a first portion of a first support substrate, the boundary wave resonator including a first piezoelectric layer and

an interdigital transducer electrode on the first piezoelectric layer; a bulk acoustic wave resonator supported by a second support substrate, the second support substrate positioned over the

boundary wave resonator, the bulk acoustic wave resonator located on an opposite side of the second support substrate as the interdigital transducer electrode of the boundary wave resonator.

[0005e] In one example, the present disclosure refers to an acoustic wave filter component comprising: a first boundary wave resonator supported by a first support substrate, the first boundary wave resonator including a first interdigital transducer electrode, the first interdigital transducer electrode located adjacent a first piezoelectric layer; a second boundary wave resonator separated from the first boundary wave resonator by a second support substrate, the second boundary wave resonator including a second interdigital transducer electrode, the second interdigital transducer electrode located adjacent a second piezoelectric layer; and a bulk acoustic wave resonator separated from the second boundary wave resonator by a third support substrate, the bulk acoustic wave resonator including a third piezoelectric layer and first and second electrodes on opposing sides of the third piezoelectric layer.

[0005f] In one example, the present disclosure refers to a packaged hybrid filter component comprising: an acoustic wave device including a piezoelectric layer and an interdigital transducer electrode on the piezoelectric layer; a support layer located over the interdigital transducer electrode; a bulk acoustic wave resonator supported by the support layer, the bulk acoustic wave resonator being included in an acoustic wave filter arranged to filter a radio frequency signal; a cap layer encapsulating the bulk acoustic wave resonator; and an external via in electrical communication with the bulk acoustic wave resonator, the external via extending through the support layer and the piezoelectric layer.

[0005g] In one example, the present disclosure refers to a packaged hybrid filter component comprising: a surface acoustic wave device including a piezoelectric layer and an interdigital transducer electrode on the piezoelectric layer; an additional layer located over the interdigital transducer electrode, the additional layer configured such that a surface acoustic wave of the surface acoustic wave device propagates along the additional layer; a bulk acoustic wave resonator supported by the additional layer, the bulk acoustic wave resonator being included in an acoustic wave filter arranged to filter a radio frequency signal;

a cap layer encapsulating the bulk acoustic wave resonator; and an external via in electrical communication with the bulk acoustic wave resonator, the external via extending through the support layer and the piezoelectric layer.

[0006] In one example, an acoustic wave filter component is disclosed. The acoustic wave filter component can include a surface acoustic wave device that includes a first piezoelectric layer, an interdigital transducer electrode on the first piezoelectric layer, and at least a portion of a temperature compensation layer positioned on the interdigital transducer electrode. The acoustic wave filter component can also include a bulk acoustic wave resonator that is supported by the temperature compensation layer. The bulk acoustic wave resonator includes a second piezoelectric layer and electrodes on opposing sides of the second piezoelectric layer.

[0007] In one example, the bulk acoustic wave resonator includes an air cavity having a shape that is impacted by the temperature compensation layer.

[0008] In one example, the bulk acoustic wave resonator includes an air cavity in physical contact with the temperature compensation layer. The air cavity can be in contact with a portion of an underlying layer along which a surface acoustic wave propagates. The air cavity can be shared with the interdigital transducer electrode of the surface acoustic wave device.

[0009] In one example, the bulk acoustic wave resonator is in contact with a portion of an underlying layer along which a surface acoustic wave propagates.

[0010] In one example, the bulk acoustic wave resonator includes a solid acoustic mirror on the temperature compensation layer. The solid acoustic mirror can be in physical contact with the temperature compensation layer. The bulk acoustic wave resonator can be laterally offset from the interdigital transducer electrode of the surface acoustic wave device.

[0011] In one example, the acoustic wave filter component further includes a support substrate. The first piezoelectric layer can be positioned on the support substrate.

[0012] In one example, the surface acoustic wave device and the bulk acoustic wave device are included in a single filter arranged to filter a radio frequency signal.

WHAT IS CLAIMED IS:

1. An acoustic wave filter component comprising:

a surface acoustic wave device including a first piezoelectric layer, an interdigital transducer electrode on the first piezoelectric layer, and at least a portion of a temperature compensation layer positioned on the interdigital transducer electrode;

a bulk acoustic wave resonator supported by the temperature compensation layer, the bulk acoustic wave resonator including a second piezoelectric layer and electrodes on opposing sides of the second piezoelectric layer; and

an internal via extending through the temperature compensation layer, the bulk acoustic wave resonator in electrical communication with the surface acoustic wave device by way of the internal via extending through the temperature compensation layer.

2. The acoustic wave filter component of claim 1 wherein the bulk acoustic wave resonator includes an air cavity having a shape that is impacted by the temperature compensation layer.

3. The acoustic wave filter component of claim 2 wherein the bulk acoustic wave resonator includes an air cavity in physical contact with the temperature compensation layer.

4. The acoustic wave filter component of claim 2 wherein the air cavity is in contact with a portion of an underlying layer along which a surface acoustic wave propagates.

5. The acoustic wave filter component of claim 2 wherein the air cavity is shared with the interdigital transducer electrode of the surface acoustic wave device.

6. The acoustic wave filter component of claim 1 wherein the bulk acoustic wave resonator is in contact with a portion of an underlying layer along which a surface acoustic wave propagates.

7. The acoustic wave filter component of claim 1 wherein the bulk acoustic wave resonator includes a solid acoustic mirror on the temperature compensation layer, the solid acoustic mirror is in physical contact with the temperature compensation layer.

8. The acoustic wave filter component of claim 7 wherein the bulk acoustic wave resonator is laterally offset from the interdigital transducer electrode of the surface acoustic wave device, and the bulk acoustic wave resonator is a film bulk acoustic wave resonator.

9. The acoustic wave filter component of claim 1 wherein at least one of the electrodes of the bulk acoustic wave resonator component extends over at least a portion of the interdigital transducer electrode.

10. The acoustic wave filter component of claim 1 wherein the internal via includes a conductive material filling an aperture in the temperature compensation layer, and the internal via is in electrical communication with a bulk acoustic wave resonator interconnect electrode extending between the internal via and one of the electrodes of the bulk acoustic wave resonator.

11. The acoustic wave filter component of claim 1 further including an air cavity between a portion of the bulk acoustic wave resonator and the temperature compensation layer, and the air cavity extends between a portion of the bulk acoustic wave resonator and a portion of the surface acoustic wave device.

12. The acoustic wave filter component of claim 1 further including a first external via extending through the first piezoelectric layer, the first external via in electrical communication with the surface acoustic wave device, and the first external via is in electrical communication with a connection pad located on a side of the first piezoelectric layer opposite the first interdigital transducer electrode.

13. The acoustic wave filter component of claim 1 further including a second external via extending through the first piezoelectric layer and through the temperature compensation layer, the second external via in electrical communication with the bulk acoustic wave resonator.

14. The acoustic wave filter component of claim 13 wherein the second external via includes a first via section extending through the first piezoelectric layer and a second via section extending through the temperature compensation layer.

15. An acoustic wave filter component comprising:

a first piezoelectric layer;

an interdigital transducer electrode over the first piezoelectric layer;

a temperature compensation layer over the interdigital transducer electrode; and

a bulk acoustic wave resonator supported by the temperature compensation layer, the bulk acoustic wave resonator including a second piezoelectric layer and electrodes on opposing sides of the second piezoelectric layer,

wherein the bulk acoustic wave resonator is electrically connected to the interdigital transducer electrode by way of an internal via extending through the temperature compensation layer.

16. The acoustic wave filter component of claim 15 wherein at least one of the electrodes of the bulk acoustic wave resonator component extends over at least a portion of the interdigital transducer electrode.

17. The acoustic wave filter component of claim 15 wherein the acoustic wave filter component further includes a second interdigital transducer electrode over the first piezoelectric layer.

18. The acoustic wave filter component of claim 15 further comprising an external via in electrical communication with the bulk acoustic wave resonator, the external via extending through the first piezoelectric layer and the temperature compensation layer.