MULTILAYER PIEZOELECTRIC SUBSTRATE

BACKGROUND

Technical Field

Embodiments of this disclosure relate to acoustic wave devices and heat dissipation structures for same.

Description of Related Technology

Acoustic wave devices, for example, surface acoustic wave (SAW) and bulk acoustic wave (BAW) devices may be utilized as components of filters in radio frequency electronic systems. For instance, filters in a radio frequency front end of a mobile phone can include acoustic wave filters. Two acoustic wave filters can be arranged as a duplexer.

SUMMARY

In one aspect, the present disclosure provides a radio frequency filter comprising of at least one acoustic wave device. The at least one acoustic wave device includes a layered substrate including a piezoelectric material layer bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer, the piezoelectric material layer including a multilayer piezoelectric substrate including three layers, a central layer of the three layers having a largest electromechanical coupling coefficient among the three layers, interdigital transducer electrodes disposed on a surface of the piezoelectric material layer, contact pads disposed on the piezoelectric material layer and in electrical contact with the interdigital transducer electrodes, external bond pads disposed on the second material layer and configured to electrically connect the acoustic wave device to a circuit board, and conductive vias passing through the layered substrate and providing electrical contact between the contact pads and external bond pads.

In another aspect, there is provided an electronics module comprising of at least one radio frequency filter including at least one acoustic wave device. The at least one acoustic wave device includes a layered substrate including a piezoelectric material layer bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer, the piezoelectric material layer including a multilayer

piezoelectric substrate including three layers, a central layer of the three layers having a largest electromechanical coupling coefficient among the three layers, interdigital transducer electrodes disposed on a surface of the piezoelectric material layer, contact pads disposed on the piezoelectric material layer and in electrical contact with the interdigital transducer electrodes, external bond pads disposed on the second material layer and configured to electrically connect the acoustic wave device to a circuit board, and conductive vias passing through the layered substrate and providing electrical contact between the contact pads and external bond pads.

In another aspect, ~~In accordance with an aspect of the present disclosure~~ there is provided an acoustic wave device. The acoustic wave device comprises a layered substrate including a piezoelectric material layer bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer, interdigital transducer electrodes disposed on a surface of the piezoelectric material layer, a cavity defined above the interdigital transducer electrodes by walls and a cap including a dielectric material, contact pads disposed on the piezoelectric material layer and in electrical contact with the interdigital transducer electrodes, external bond pads disposed on the ~~second material layer~~ cap on an opposite side of the cap from the cavity, and conductive vias passing through the ~~layered substrate~~cap and providing electrical contact between the contact pads and external bond pads.

In another aspect, there is provided an acoustic wave device. The acoustic wave device comprises a layered substrate including a piezoelectric material layer bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer, interdigital transducer electrodes disposed on a surface of the piezoelectric material layer, contact pads disposed on the piezoelectric material layer and in electrical contact with the interdigital transducer electrodes, external bond pads disposed on the second material layer and configured to electrically connect the acoustic wave device to a circuit board, and conductive vias passing through the layered substrate and providing electrical contact between the contact pads and external bond pads, each of the conductive vias passing in a straight line through the layered substrate from the contact pads to the external bond pads.

In some ~~embodiments~~examples, the second material layer includes a dielectric material. The second material layer may include spinel. The second material layer may include silicon.

In some ~~embodiments~~examples, the acoustic wave device further comprises a cavity defined above the interdigital transducer electrodes by walls and a cap including a dielectric material.

In some ~~embodiments~~examples, the acoustic wave device further comprises a bonding layer that bonds the piezoelectric material layer to the second material layer. The bonding layer may comprise silicon dioxide.

In some ~~embodiments~~examples, the second material layer has a thickness of between about 50 μm and about 150 μm.

In some ~~embodiments~~examples, the piezoelectric material layer has a thickness of between about 0.3 μm and about 20 μm.

In some ~~embodiments~~examples, the acoustic wave device is configured as a surface acoustic wave resonator.

In some ~~embodiments~~examples, a radio frequency filter includes the surface acoustic wave resonator. An electronics module may include the radio frequency filter. An electronic device may include the electronics module.

In some examples, the piezoelectric material layer comprises a multilayer piezoelectric substrate including three layers, a central layer of the three layers having a largest electromechanical coupling coefficient among the three layers.

In some examples, each of the conductive vias pass in a straight line through the layered substrate from the contact pads to the external bond pads.

~~In accordance with another aspect, there is provided a filter. The radio frequency filter comprises at least one acoustic wave device. The at least one acoustic wave device includes a layered substrate including a piezoelectric material layer bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer, interdigital transducer electrodes disposed on a surface of the piezoelectric material layer, contact pads disposed on the piezoelectric material layer and in electrical contact with the interdigital transducer electrodes, external bond pads disposed on the second material layer, and conductive vias passing through the layered substrate and providing electrical contact between the contact pads and external bond pads.~~

~~In accordance with another aspect, there is provided an electronics module. The electronics module comprises at least one radio frequency filter including at least one acoustic wave device. The at least one acoustic wave device includes a layered substrate including a piezoelectric material layer bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer, interdigital transducer electrodes disposed on a surface of the piezoelectric material layer, contact pads disposed on the piezoelectric material layer and in electrical contact with the interdigital transducer electrodes, external bond pads disposed on the second material layer,~~

and conductive vias passing through the layered substrate and providing electrical contact between the contact pads and external bond pads.

In accordance with another aspect, there is provided an acoustic wave device. The acoustic wave device comprises a layered substrate including a piezoelectric material layer

~~bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer, interdigital transducer electrodes disposed on a surface of the piezoelectric material layer, contact pads disposed on the piezoelectric material layer and in electrical contact with the interdigital transducer electrodes, a cavity defined above the interdigital transducer electrodes by walls and a cap including a dielectric material, external bond pads disposed on the cap on an opposite side of the cap from the cavity, and conductive vias passing through the cap and providing electrical contact between the contact pads and external bond pads.~~

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of this disclosure will now be described, by way of non-limiting example, with reference to the accompanying drawings.

FIG. 1A is a simplified plan view of an example of a surface acoustic wave resonator;

FIG. 1B is a simplified plan view of another example of a surface acoustic wave resonator;

FIG. 1C is a simplified plan view of another example of a surface acoustic wave resonator;

FIG. 2 is a cross-sectional view of an embodiment of a packaged surface acoustic wave device;

FIG. 3 is a cross-sectional view of another embodiment of a packaged surface acoustic wave device;

FIG. 4 is a cross-sectional view of another embodiment of a packaged surface acoustic wave device;

FIG. 5 is a cross-sectional view of another embodiment of a packaged surface acoustic wave device;

FIG. 6 is a cross-sectional view of another embodiment of a packaged surface acoustic wave device;

FIG. 7 is a cross-sectional view of another embodiment of a packaged surface acoustic wave device;

CLAIMS

What is claimed is:

1. An acoustic wave device comprising:

a layered substrate including a piezoelectric material layer bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer;

interdigital transducer electrodes disposed on a surface of the piezoelectric material layer;

contact pads disposed on the piezoelectric material layer and in electrical contact with the interdigital transducer electrodes;

external bond pads disposed on the second material layer; and

conductive vias passing through the layered substrate and providing electrical contact between the contact pads and external bond pads.

2. The acoustic wave device of claim 1 wherein the second material layer includes a dielectric material.

3. The acoustic wave device of claim 2 wherein the second material layer includes spinel.

4. The acoustic wave device of claim 2 wherein the second material layer includes silicon.

5. The acoustic wave device of claim 1 further comprising a cavity defined above the interdigital transducer electrodes by walls and a cap including a dielectric material.

6. The acoustic wave device of claim 1 further comprising a bonding layer that bonds the piezoelectric material layer to the second material layer.

7. The acoustic wave device of claim 6 wherein the bonding layer comprises silicon dioxide.

8. The acoustic wave device of claim 1 wherein the second material layer has a thickness of between about 50 μm and about 150 μm.

9. The acoustic wave device of claim 1 wherein the piezoelectric material layer has a thickness of between about 0.3 μm and about 20 μm.

10. The acoustic wave device of claim 1 configured as a surface acoustic wave resonator.

11. A radio frequency filter including the surface acoustic wave resonator of claim 10.

12. An electronics module including the radio frequency filter of claim 11.

13. An electronic device including the electronics module of claim 12.

14. A radio frequency filter comprising:

at least one acoustic wave device, the at least one acoustic wave device including:

a layered substrate including a piezoelectric material layer bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer;

interdigital transducer electrodes disposed on a surface of the piezoelectric material layer;

contact pads disposed on the piezoelectric material layer and in electrical contact with the interdigital transducer electrodes;

external bond pads disposed on the second material layer; and

conductive vias passing through the layered substrate and providing electrical contact between the contact pads and external bond pads.

15. An electronics module comprising:

at least one radio frequency filter including at least one acoustic wave device, the at least one acoustic wave device including:

a layered substrate including a piezoelectric material layer bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer;

interdigital transducer electrodes disposed on a surface of the piezoelectric material layer;

contact pads disposed on the piezoelectric material layer and in electrical contact with the interdigital transducer electrodes;

external bond pads disposed on the second material layer; and

conductive vias passing through the layered substrate and providing electrical contact between the contact pads and external bond pads.

16. An acoustic wave device comprising:

a layered substrate including a piezoelectric material layer bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer;

interdigital transducer electrodes disposed on a surface of the piezoelectric material layer;

contact pads disposed on the piezoelectric material layer and in electrical contact with the interdigital transducer electrodes;

a cavity defined above the interdigital transducer electrodes by walls and a cap including a dielectric material;

external bond pads disposed on the cap on an opposite side of the cap from the cavity; and

conductive vias passing through the cap and providing electrical contact between the contact pads and external bond pads.

CLAIMS

What is claimed is:

1. A radio frequency filter comprising:

at least one acoustic wave device, the at least one acoustic wave device including:

a layered substrate including a piezoelectric material layer bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer, the piezoelectric material layer including a multilayer piezoelectric substrate including three layers, a central layer of the three layers having a largest electromechanical coupling coefficient among the three layers;

interdigital transducer electrodes disposed on a surface of the piezoelectric material layer;

contact pads disposed on the piezoelectric material layer and in electrical contact with the interdigital transducer electrodes;

external bond pads disposed on the second material layer and configured to electrically connect the acoustic wave device to a circuit board; and

conductive vias passing through the layered substrate and providing electrical contact between the contact pads and external bond pads.

2. An electronics module comprising:

at least one radio frequency filter including at least one acoustic wave device, the at least one acoustic wave device including:

a layered substrate including a piezoelectric material layer bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer, the piezoelectric material layer including a multilayer piezoelectric substrate including three layers, a central layer of the three layers having a largest electromechanical coupling coefficient among the three layers;

interdigital transducer electrodes disposed on a surface of the piezoelectric material layer;

contact pads disposed on the piezoelectric material layer and in electrical contact with the interdigital transducer electrodes;

external bond pads disposed on the second material layer and configured to electrically connect the acoustic wave device to a circuit board; and

conductive vias passing through the layered substrate and providing electrical contact between the contact pads and external bond pads.

3. An acoustic wave device comprising:

a layered substrate including a piezoelectric material layer bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer;

interdigital transducer electrodes disposed on a surface of the piezoelectric material layer;

a cavity defined above the interdigital transducer electrodes by walls and a cap including a dielectric material;

contact pads disposed on the piezoelectric material layer within the cavity and in electrical contact with the interdigital transducer electrodes;

external bond pads disposed on the cap on an opposite side of the cap from the cavity; and

conductive vias passing through the cap and providing electrical contact between the contact pads and external bond pads.

4. The acoustic wave device of claim 3 wherein each of the conductive vias pass in a straight line through the layered substrate from the contact pads to the external bond pads.

5. An acoustic wave device comprising:

a layered substrate including a piezoelectric material layer bonded to a second material layer including a material having a higher thermal conductivity than the piezoelectric material layer;

interdigital transducer electrodes disposed on a surface of the piezoelectric material layer;

contact pads disposed on the piezoelectric material layer and in electrical contact with the interdigital transducer electrodes;

external bond pads disposed on the second material layer and configured to electrically connect the acoustic wave device to a circuit board; and

conductive vias passing through the layered substrate and providing electrical contact between the contact pads and external bond pads, each of the conductive vias passing in a straight line through the layered substrate from the contact pads to the external bond pads.

6. The acoustic wave device of claim 5 wherein the second material layer includes a dielectric material.

7. The acoustic wave device of claim 6 wherein the second material layer includes spinel.

8. The acoustic wave device of claim 6 wherein the second material layer includes silicon.

9. The acoustic wave device of claim 5 further comprising a bonding layer that bonds the piezoelectric material layer to the second material layer.

10. The acoustic wave device of claim 9 wherein the bonding layer comprises silicon dioxide.

11. The acoustic wave device of claim 5 wherein the second material layer has a thickness of between about 50 μm and about 150 μm.

12. The acoustic wave device of claim 5 wherein the piezoelectric material layer has a thickness of between about 0.3 μm and about 20 μm.

13. The acoustic wave device of claim 5 configured as a surface acoustic wave resonator.

14. A radio frequency filter including the surface acoustic wave resonator of claim 13.

15. An electronics module including the radio frequency filter of claim 14.

16. An electronic device including the electronics module of claim 15.

17. The acoustic wave device of claim 5 wherein the piezoelectric material layer comprises a multilayer piezoelectric substrate including three layers, a central layer of the three layers having a largest electromechanical coupling coefficient among the three layers.

18. The acoustic wave device of claim 5 wherein each of the conductive vias pass in a straight line through the layered substrate from the contact pads to the external bond pads.