PACKAGED SURFACE ACOUSTIC WAVE DEVICES

CROSS REFERENCE TO PRIORITY APPLICATIONS

[0001] Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet as filed with the present application are hereby incorporated by reference under 37 C.F.R. § 1.57. This application claims the benefit of priority under 35 U.S.C. § 119(e) of U.S. Provisional Application No. 62/725,133, filed August 30, 2018 and entitled "PACKAGED SURFACE ACOUSTIC WAVE DEVICES," the disclosure of which is hereby incorporated by reference in its entirety.

BACKGROUND

Technical Field

[0002] Embodiments of this disclosure relate to packaged surface acoustic wave devices.

Description of Related Technology

[0003] A surface acoustic wave filter can include a plurality of surface acoustic wave resonators arranged to filter a radio frequency signal. Each resonator can include a surface acoustic wave device. Surface acoustic wave filters can be implemented in radio frequency electronic systems. For instance, filters in a radio frequency front end of a mobile phone can include surface acoustic wave filters. A plurality of acoustic wave filters can be arranged as a multiplexer. For example, two surface acoustic wave filters can be arranged as a duplexer.

[0004] Surface acoustic wave devices can be enclosed within a package to protect the surface acoustic wave devices. The package can add to the size of a packaged surface acoustic wave device. There is a desire for smaller and thinner packaged surface acoustic wave devices.

SUMMARY ~~OF CERTAIN INVENTIVE ASPECTS~~

[0004a] In an aspect, the present disclosure refers to a packaged surface acoustic wave device comprising: a cavity roof over an interdigital transducer electrode of

a surface acoustic wave device; a conductive structure over the cavity roof; and a photosensitive buffer coat layer over the conductive structure, the packaged surface acoustic wave device having a height of 220 micrometers or less; the packaged surface acoustic wave device further comprising a piezoelectric substrate having a first side on which the interdigital transducer electrode is disposed, and a cavity wall on the first side of the piezoelectric substrate and supporting the cavity roof, wherein an edge portion of the first side of the piezoelectric substrate is free from the photosensitive buffer coat layer.

[0004b] In an aspect, the present disclosure refers to a packaged surface acoustic wave device comprising: a cavity structure supported by a die and cooperating the die to encapsulate an interdigital transducer electrode of a surface acoustic wave device; a conductive structure extending over a portion of an outer surface of the cavity structure; and an insulating layer extending over the conductive structure, a portion of the insulating layer overlying a portion of the conductive structure having a thickness of less than 15 micrometers; the die comprising a laser-marked piezoelectric substrate having a first side supporting the cavity structure, wherein an edge portion of the first side of the laser-marked piezoelectric substrate is free from the insulating layer.

[0004c] In an aspect, the present disclosure refers to a packaged surface acoustic wave device comprising: a piezoelectric substrate; a packaging structure supported by a first surface of the piezoelectric substrate and defining a cavity, the packaging structure including an outer layer including photosensitive resin; and a plurality of interdigital transducer electrodes supported by the piezoelectric substrate and located within the cavity; wherein an edge portion of the first surface of the piezoelectric substrate is free from the photosensitive resin.

[0004d] In an aspect, the present disclosure refers to a method of manufacturing a packaged surface acoustic wave device, the method comprising: forming a photosensitive resin over a conductive structure, a portion of the conductive structure located over a cavity roof over an interdigital transducer electrode of the surface acoustic wave device; forming a conductive terminal in contact with the conductive structure, at least a portion of the conductive terminal extending through an aperture extending through the photosensitive resin; and forming an edge of a piezoelectric substrate on which the interdigital transducer electrode is disposed that is free from the photosensitive resin.

[0004e] In an aspect, the present disclosure refers to a method of manufacturing a packaged surface acoustic wave device, the method comprising: forming a cavity structure encapsulating interdigital transducer electrodes of a surface acoustic wave device, the interdigital transducer electrodes supported by a piezoelectric substrate; forming a conductive structure extending over portions of an outer surface of the cavity structure; forming a photoresist layer over the conductive structure, a portion of the photoresist layer extending over a portion of the conductive structure having a thickness of less than 15 micrometers; and removing portions of the photoresist layer within 10 micrometers of the edge of the die.

[0004f] In an aspect, the present disclosure refers to a method of manufacturing a packaged surface acoustic wave device, the method comprising: forming a cavity structure extending over interdigital transducer electrodes of the surface acoustic wave device; forming a conductive structure extending over portions of an outer surface of the cavity structure; forming a photosensitive resin layer over the conductive structure, a portion of the photosensitive resin layer having an aperture extending therethrough and exposing a portion of the conductive structure; and forming an edge of a piezoelectric substrate on which the interdigital transducer electrode is disposed that is free from the photosensitive resin layer.

[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.

[0006] One ~~aspect~~ example of this disclosure is a packaged surface acoustic wave device. The packaged surface acoustic wave device includes a cavity roof over an interdigital transducer electrode of a surface acoustic wave device, a conductive structure over the cavity roof, and a photosensitive buffer coat layer over the conductive structure, the packaged surface acoustic wave device having a height of 220 micrometers or less.

[0007] The packaged surface acoustic wave device can have a height of 200 micrometers or less. The photosensitive buffer coat layer can have a height of 15 micrometers or less.

[0008] The packaged surface acoustic wave device can further include a piezoelectric substrate having a first side on which the interdigital transducer electrode is disposed, and a cavity wall on the first side of the piezoelectric substrate and supporting the cavity roof. An edge portion of the first side of the piezoelectric substrate can be free from the photosensitive buffer coat layer.

[0009] The packaged surface acoustic wave device can further include a piezoelectric substrate having a first side and a second side opposite the first side, the interdigital transducer electrode being on the first side, and a marking extending into the second side, the marking extending 1 micrometer or less into the piezoelectric substrate. The packaged surface acoustic wave device of claim 1 can further include a terminal in physical contact with the conductive structure though an opening in the photosensitive buffer coat layer.

[0010] The photosensitive buffer coat layer can include phenol resin. The photosensitive buffer coat layer can have a negative photosensitivity.

[0011] The surface acoustic wave device can include a plurality of surface acoustic wave resonators configured to filter a radio frequency signal.

[0012] Another example ~~aspect~~ of this disclosure is a packaged surface acoustic wave device that includes a cavity structure supported by a die and cooperating the die to encapsulate an interdigital transducer electrode of a surface acoustic wave device, a conductive structure extending over a portion of an outer surface of the cavity structure, and a insulating layer extending over the conductive structure, a portion of the insulating layer overlying a portion of the conductive structure having a thickness of less than 15 micrometers.

[0013] The cavity structure can include a cavity wall supported by a first surface of the die and a cavity roof extending over the interdigital transducer electrode and supported by the cavity wall. The packaged surface acoustic wave device can further include a plurality of terminals, each of the terminals extending through a portion of the insulating layer and contacting a portion of the conductive structure.

[0014] The insulating layer can include a photoresist material. The insulating layer can include a negative photoresist.

[0015] The die can include a laser-marked piezoelectric substrate having a first side and a second side, the first side supporting the cavity structure, the second side of the laser-marked piezoelectric substrate having a laser-marked section.

[0016] Another example ~~aspect~~ of this disclosure is a packaged surface acoustic wave device that includes a piezoelectric substrate, a packaging structure supported by a first surface of the piezoelectric substrate and defining a cavity, the packaging structure including an outer layer including photosensitive resin, and a plurality of interdigital transducer electrodes supported by the piezoelectric substrate and located within the cavity.

[0017] The packaging structure can include a cavity roof and a cavity wall, the cavity roof and the cavity wall both located between a portion of the outer layer and the plurality of interdigital transducer electrodes.

[0018] The packaging structure can include a conductive structure in electrical communication with at least one of the plurality of interdigital transducer electrodes. The packaging structure can include at least one terminal overlying a portion of the outer layer and extending through a portion of the outer layer to contact the conductive structure.

[0019] Another example ~~aspect~~ of this disclosure is a method of manufacturing a packaged surface acoustic wave device, the method including forming a photosensitive resin over a conductive structure, a portion of the conductive structure located over a cavity roof over an interdigital transducer electrode of the surface acoustic wave device, and forming a conductive terminal in contact with the conductive structure, at least a portion of the conductive terminal extending through an aperture extending through the photosensitive resin.

[0020] The method can additionally include exposing portions of the photosensitive resin to light to develop portions of the photosensitive resin and removing unexposed portions of the photosensitive resin. The method can additionally include

curing the photosensitive resin after removing unexposed portions of the photosensitive resin. Exposing portions of the photosensitive resin to light can include masking a portion of the photosensitive resin extending over a portion of the conductive structure to form the aperture extending through the photosensitive resin.

[0021] Forming the terminal can additionally include forming a conductive layer extending over the aperture extending through the photosensitive resin. The aperture can extend through a portion of the photosensitive resin having a thickness of 15 micrometers or less.

[0022] The photosensitive resin can include phenol resin. The photosensitive resin can have a negative photosensitivity.

[0023] The can additionally include laser marking a piezoelectric substrate on which the interdigital transducer electrode is disposed.

[0024] The packaged surface acoustic wave device can have a height of less than 220 micrometers.

[0025] Another example ~~aspect~~ of this disclosure is a method of manufacturing a packaged surface acoustic wave device, the method including forming a cavity structure encapsulating interdigital transducer electrodes of a surface acoustic wave device, the interdigital transducer electrodes supported by a piezoelectric substrate, forming a conductive structure extending over portions of an outer surface of the cavity structure, and forming a photoresist layer over the conductive structure, a portion of the photoresist layer extending over a portion of the conductive structure having a thickness of less than 15 micrometers.

[0026] The method can additionally include patterning the photoresist layer to form a photoresist buffer coat extending over the conductive structure and the cavity structure and curing the photoresist layer. The photoresist buffer coat can include a sidewall portion in contact with the piezoelectric substrate and circumscribing the cavity structure. A portion of the conductive structure can be in contact with the piezoelectric substrate.

[0027] Forming the photoresist layer over the conductive structure can include using a spin-on process to planarize the photoresist layer. The method can additionally include removing portions of the photoresist layer within 10 micrometers of the edge of the die.

[0028] Another example ~~aspect~~ of this disclosure is a method of manufacturing a packaged surface acoustic wave device, the method including forming a cavity structure extending over interdigital transducer electrodes of the surface acoustic wave device, and forming a conductive structure extending over portions of an outer surface of the cavity structure, and forming a photosensitive resin layer over the conductive structure, a portion of the photosensitive resin layer having an aperture extending therethrough and exposing a portion of the conductive structure.

[0029] Forming the conductive structure can include depositing a seed layer over the cavity structure and plating the conductive structure onto the seed layer. Forming the conductive structure further can include masking portions of the seed layer prior to plating the conductive structure onto the seed layer.

[0030] The conductive structure can include a gap extending through a portion thereof and exposing a portion of the cavity structure, and the photosensitive resin layer can fill the gap. The method can additionally include forming a conductive terminal extending through an aperture in the photosensitive resin layer and in electrical communication with the conductive structure.

[0031] Another example ~~aspect~~ of this disclosure is a packaged surface acoustic wave device that includes a piezoelectric substrate having a first side and a second side, an interdigital transducer electrode encapsulated within a package structure and supported by the first side of the piezoelectric substrate, and a marking formed in the second side of the piezoelectric substrate.

[0032] The marking can extend less than 1 micrometer into the second side of the piezoelectric substrate. The marking can extend into less than 1% of a thickness of the piezoelectric substrate. The marking can be formed by a laser.

[0033] The piezoelectric substrate can include lithium niobate. The piezoelectric substrate can include lithium tantalite.

[0034] The package structure can include a cavity structure encapsulating the interdigital transducer electrode and an outer coat including a photosensitive resin. A total thickness of the packaged surface acoustic wave device can be less than 220 micrometers.

[0035] The package structure can include a photosensitive resin buffer coat. The photosensitive resin buffer coat can include phenol resin. The photosensitive resin buffer coat can include a negative photoresist. The packaged surface acoustic wave

device can additionally include a plurality of terminals extending through apertures in the photosensitive resin buffer coat.

[0036] Another example ~~aspect~~ of this disclosure is a packaged surface acoustic wave device that includes a laser-marked piezoelectric substrate having a first side and a second side, the second side of the laser-marked piezoelectric substrate having a laser-marked section, an interdigital transducer electrode supported by the first side of the laser marked piezoelectric substrate, and a structure supported by the first side of the laser-marked piezoelectric substrate defining a cavity enclosing the interdigital transducer electrode.

[0037] The laser-marked section can have been exposed to a deep ultraviolet laser. The laser-marked section can include laser markings extending less than 1 micrometer into the second side of the piezoelectric substrate.

[0038] The laser-marked piezoelectric substrate can include lithium niobate. The laser-marked piezoelectric substrate can include lithium tantalite.

[0039] The package structure can include a photosensitive resin buffer coat. The photosensitive resin buffer coat can include phenol resin. The photosensitive resin buffer coat can include a negative photoresist. Another example ~~aspect~~ of this disclosure is a method of marking a packaged surface acoustic wave device, the method including grinding a back side of a piezoelectric substrate, the back side being opposite a front side of the piezoelectric substrate on which an interdigital transducer electrode of the surface acoustic wave device is disposed, and laser marking the piezoelectric substrate.

[0040] The laser marking can form a marking that extends less than 1 micron into the piezoelectric substrate. The laser marking includes can include a wavelength of laser light that allows the piezoelectric substrate to maintain structural integrity.

[0041] The laser marking can include using a deep ultraviolet laser. The laser marking can include using a laser with a wavelength of about 266 nanometers.

[0042] Grinding the back side of the piezoelectric substrate can include grinding the back side of the piezoelectric substrate until a thickness of the piezoelectric substrate is about 130 micrometers.

[0043] The piezoelectric substrate can include lithium niobate. The method of claim 62 where the piezoelectric substrate can include lithium tantalite.

[0044] The method can additionally include forming a structure supported by the front side of the piezoelectric substrate and defining a cavity enclosing the interdigital

transducer electrode. The structure supported by the front side of the piezoelectric substrate can be formed before grinding the back side of the piezoelectric substrate. Forming the structure supported by the front side of the piezoelectric substrate can include forming a photosensitive resin buffer coat.

[0045] Another example ~~aspect~~ of this disclosure is a method of marking a packaged surface acoustic wave device, the method including forming a packaging structure on a first surface of a piezoelectric substrate on which an interdigital transducer electrode of the surface acoustic wave device is disposed, the packaging structure encapsulating the interdigital transducer electrode in a cavity, and directly marking a second surface of the piezoelectric substrate to form a marked portion of the piezoelectric substrate.

[0046] Directly marking the second surface of the piezoelectric substrate can include exposing the marked portion of the second surface of the piezoelectric substrate to laser light. The laser light can include deep ultraviolet light. The laser light can have a wavelength of about 266 nanometers.

[0047] Forming a packaging structure can include forming a layer of photosensitive resin and patterning the layer of photosensitive resin. The photosensitive resin can include a phenol resin. Forming a packaging structure can include forming a conductive terminal extending through the layer of photosensitive resin.

[0048] The marking can extend less than 1 micron into the piezoelectric substrate. The packaged surface acoustic wave device can have a thickness of less than 220 micrometers.

[0049] Another example ~~aspect~~ of this disclosure is a packaged surface acoustic wave device that includes a cavity roof over interdigital transducers of a surface acoustic wave device, a plate over the cavity roof, and a photosensitive buffer coat layer over the plate, the packaged surface acoustic wave device having a height of 220 micrometers or less.

[0050] The packaged surface acoustic wave device can have a height of 200 micrometers or less. The photosensitive buffer coat layer can have a height of 15 micrometers or less.

[0051] The packaged surface acoustic wave device can additionally include a piezoelectric substrate having a first side on which the interdigital transducers are disposed, an edge portion of the first side of the piezoelectric substrate can be free from the photosensitive buffer coat layer.

[0052] The packaged surface acoustic wave device can additionally include a piezoelectric substrate having a first side and a second side opposite the first side, the interdigital transducers can be on the first side, and marking can extend into the second side. The marking can extend 1 micrometer or less into the piezoelectric substrate.

[0053] The packaged surface acoustic wave device can additionally include a terminal in physical contact with the plate though an opening in the photosensitive buffer coat layer.

[0054] The photosensitive buffer coat layer can include phenol resin. The photosensitive buffer coat layer can have a negative photosensitivity.

[0055] The packaged surface acoustic wave device can include a surface acoustic wave device configured to filter a radio frequency signal.

[0056] Another example ~~aspect~~ of this disclosure is a packaged surface acoustic wave device that includes a piezoelectric substrate having a first side and a second side opposite the first side, the second side having markings extending therein, a cavity roof over interdigital transducers of the surface acoustic wave device on the first side of the piezoelectric substrate, a plate over the cavity roof, and an insulating layer over the plate.

[0057] Another example ~~aspect~~ of this disclosure is a packaged surface acoustic wave device that includes a piezoelectric substrate, a cavity roof over interdigital transducers of the surface acoustic wave device, the interdigital transducers being disposed on the piezoelectric substrate, a plate over the cavity roof, and an insulating layer over the plate, an edge portion of the piezoelectric substrate being free from the insulating layer.

[0058] Another example ~~aspect~~ of this disclosure is a packaged surface acoustic wave device that includes a cavity roof over interdigital transducers of a surface acoustic wave device, a plate over the cavity roof, and an insulating layer over the plate, the insulating layer having a thickness of 10 micrometers or less, and the packaged surface acoustic wave device having a height of 200 micrometers or less.

[0059] Another example ~~aspect~~ of this disclosure is a method of manufacturing a packaged surface acoustic wave device, the method including forming a photosensitive resin over a plate, the plate being positioned over a cavity roof enclosing interdigital transducers of the surface acoustic wave device, and forming a terminal of the surface acoustic wave device over the photosensitive resin such that the terminal is in contact with the plate.

[0060] The method can additionally include exposing portions of the photosensitive resin to light and making other portions of the photosensitive resin to provide an opening though the photosensitive resin, where forming the terminal can include filling the opening with material of the terminal.

[0061] The method can additionally include exposing the photosensitive resin to light and making other portions of the photosensitive resin to provide an edge of a piezoelectric substrate free from the photosensitive resin, and the interdigital transducer electrodes can be positioned on the piezoelectric substrate.

[0062] The photosensitive resin can have a thickness of 15 micrometers or less. The photosensitive resin can include phenol resin.

[0063] The method can additionally include laser marking a piezoelectric substrate on which the interdigital transducers are disposed.

[0064] Another example ~~aspect~~ of this disclosure is a method of marking a packaged surface acoustic wave device, the method including grinding a back side of a piezoelectric substrate, the back side being opposite a front side of the piezoelectric substrate on which interdigital transducers of the surface acoustic wave device are disposed, and laser marking the piezoelectric substrate.

[0065] The marking can extend less than 1 micron into the piezoelectric substrate.

[0066] The laser marking can include applying a wavelength of laser light that allows the piezoelectric substrate to maintain structural integrity. The laser marking can include using a deep ultraviolet laser.

[0067] For purposes of summarizing the disclosure, certain aspects, advantages and novel features of the innovations have been described herein. It is to be understood that not necessarily all such advantages may be achieved in accordance with any particular embodiment. Thus, the innovations may be embodied or carried out in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other advantages as may be taught or suggested herein.

WHAT IS CLAIMED IS:

1. A packaged surface acoustic wave device comprising:

a cavity roof over an interdigital transducer electrode of a surface acoustic wave device;

a conductive structure over the cavity roof; and

a photosensitive buffer coat layer over the conductive structure, the packaged surface acoustic wave device having a height of 220 micrometers or less;

the packaged surface acoustic wave device further comprising a piezoelectric substrate having a first side on which the interdigital transducer electrode is disposed, and a cavity wall on the first side of the piezoelectric substrate and supporting the cavity roof, wherein an edge portion of the first side of the piezoelectric substrate is free from the photosensitive buffer coat layer.

2. The packaged surface acoustic wave device of claim 1 wherein the packaged surface acoustic wave device has a height of 200 micrometers or less.

3. The packaged surface acoustic wave device of claim 1 wherein the photosensitive buffer coat layer has a height of 15 micrometers or less.

~~4. The packaged surface acoustic wave device of claim 1 further comprising a piezoelectric substrate having a first side on which the interdigital transducer electrode is disposed, and a cavity wall on the first side of the piezoelectric substrate and supporting the cavity roof.~~

~~5. The packaged surface acoustic wave device of claim 4 wherein an edge portion of the first side of the piezoelectric substrate is free from the photosensitive buffer coat layer.~~

~~6.~~4. The packaged surface acoustic wave device of claim 1 further comprising a piezoelectric substrate having a first side and a second side opposite the first side, the interdigital transducer electrode being on the first side, and a marking extending into the second side, the marking extending 1 micrometer or less into the piezoelectric substrate.

~~7.~~5. The packaged surface acoustic wave device of claim 1 further comprising a terminal in physical contact with the conductive structure though an opening in the photosensitive buffer coat layer.

~~8.~~6. The packaged surface acoustic wave device of claim 1 wherein the photosensitive buffer coat layer includes phenol resin.

~~9.~~7. The packaged surface acoustic wave device of claim 1 wherein the photosensitive buffer coat layer has a negative photosensitivity.

~~10.~~8. The packaged surface acoustic wave device of claim 1 wherein the surface acoustic wave device includes a plurality of surface acoustic wave resonators configured to filter a radio frequency signal.

~~11.~~9. A packaged surface acoustic wave device comprising:

a cavity structure supported by a die and cooperating the die to encapsulate an interdigital transducer electrode of a surface acoustic wave device;

a conductive structure extending over a portion of an outer surface of the cavity structure; and

an insulating layer extending over the conductive structure, a portion of the insulating layer overlying a portion of the conductive structure having a thickness of less than 15 micrometers;

the die comprising a laser-marked piezoelectric substrate having a first side supporting the cavity structure, wherein an edge portion of the first side of the laser-marked piezoelectric substrate is free from the insulating layer.

~~12.~~10. The packaged surface acoustic wave device of claim ~~11~~ 9 wherein the cavity structure includes a cavity wall supported by a first surface of the die and a cavity roof extending over the interdigital transducer electrode and supported by the cavity wall.

~~13.~~11. The packaged surface acoustic wave device of claim ~~12~~ 10 further comprising a plurality of terminals, each of the terminals extending through a portion of the insulating layer and contacting a portion of the conductive structure.

~~14.~~12. The packaged surface acoustic wave device of claim ~~11~~ 9 wherein the insulating layer includes a photoresist material.

~~15.~~13. The packaged surface acoustic wave device of claim ~~14~~ 12 wherein the insulating layer includes a negative photoresist.

~~16.~~14. The packaged surface acoustic wave device of claim ~~14~~ 12 wherein ~~the die comprises a laser-marked piezoelectric substrate having a first side and a second side, the first side supporting the cavity structure, the~~ a second side of the laser-marked piezoelectric substrate ~~having~~ comprises a laser-marked section.

~~17.~~15. A packaged surface acoustic wave device comprising:

a piezoelectric substrate;

a packaging structure supported by a first surface of the piezoelectric substrate and defining a cavity, the packaging structure including an outer layer including photosensitive resin; and

a plurality of interdigital transducer electrodes supported by the piezoelectric substrate and located within the cavity;

wherein an edge portion of the first surface of the piezoelectric substrate is free from the photosensitive resin.

~~18.~~16. The packaged surface acoustic wave device of claim ~~17~~ 15 wherein the packaging structure includes a cavity roof and a cavity wall, the cavity roof and the cavity wall both located between a portion of the outer layer and the plurality of interdigital transducer electrodes.

~~19.~~17. The packaged surface acoustic wave device of claim ~~17~~ 15 wherein the packaging structure includes a conductive structure in electrical communication with at least one of the plurality of interdigital transducer electrodes.

~~20.~~18. The packaged surface acoustic wave device of claim ~~19~~ 17 wherein the packaging structure includes at least one terminal overlying a portion of the outer layer and extending through a portion of the outer layer to contact the conductive structure.

~~21.~~19. A method of manufacturing a packaged surface acoustic wave device, the method comprising:

forming a photosensitive resin over a conductive structure, a portion of the conductive structure located over a cavity roof over an interdigital transducer electrode of the surface acoustic wave device; ~~and~~

forming a conductive terminal in contact with the conductive structure, at least a portion of the conductive terminal extending through an aperture extending through the photosensitive resin; and

forming an edge of a piezoelectric substrate on which the interdigital transducer electrode is disposed that is free from the photosensitive resin.

~~22.~~20. The method of claim ~~21~~ 19 further comprising exposing portions of the photosensitive resin to light to develop the portions of the photosensitive resin and removing unexposed portions of the photosensitive resin.

~~23.~~21. The method of claim ~~22~~ 20 further comprising curing the photosensitive resin after removing unexposed portions of the photosensitive resin.

~~24.~~22. The method of claim ~~22~~ 20 wherein the exposing portions of the photosensitive resin to light includes masking a portion of the photosensitive resin extending over a portion of the conductive structure to form the aperture extending through the photosensitive resin.

~~25.~~23. The method of claim ~~21~~ 19 wherein the forming the terminal includes forming a conductive layer extending over the aperture extending through the photosensitive resin.

~~26.~~24. The method of claim ~~21~~ 19 wherein the aperture extends through a portion of the photosensitive resin having a thickness of 15 micrometers or less.

~~27.~~25. The method of claim ~~21~~ 19 wherein the photosensitive resin includes phenol resin.

~~28.~~26. The method of claim ~~21~~ 19 further comprising laser marking ~~a~~ the piezoelectric substrate ~~on which the interdigital transducer electrode is disposed~~.

~~29.~~27. The method of claim ~~21~~ 19 wherein the packaged surface acoustic wave device has a height of less than 220 micrometers.

~~30.~~28. A method of manufacturing a packaged surface acoustic wave device, the method comprising:

forming a cavity structure encapsulating interdigital transducer electrodes of a surface acoustic wave device, the interdigital transducer electrodes supported by a piezoelectric substrate;

forming a conductive structure extending over portions of an outer surface of the cavity structure; ~~and~~

forming a photoresist layer over the conductive structure, a portion of the photoresist layer extending over a portion of the conductive structure having a thickness of less than 15 micrometers; and

removing portions of the photoresist layer within 10 micrometers of an edge of the piezoelectric substrate.

~~31.~~29. The method of claim ~~30~~ 28 further comprising patterning the photoresist layer to form a photoresist buffer coat extending over the conductive structure and the cavity structure and curing the photoresist layer.

~~32.~~30. The method of claim ~~31~~ 29 wherein the photoresist buffer coat includes a sidewall portion in contact with the piezoelectric substrate and circumscribing the cavity structure.

~~33.~~31. The method of claim ~~32~~ 30 wherein another portion of the conductive structure is in contact with the piezoelectric substrate.

~~34.~~32. The method of claim ~~30~~ 28 wherein the forming the photoresist layer over the conductive structure includes using a spin-on process to planarize the photoresist layer.

~~35. The method of claim 30 further comprising removing portions of the photoresist layer within 10 micrometers of the edge of the die.~~

~~36.~~33. A method of manufacturing a packaged surface acoustic wave device, the method comprising:

forming a cavity structure extending over interdigital transducer electrodes of the surface acoustic wave device;

forming a conductive structure extending over portions of an outer surface of the cavity structure; ~~and~~

forming a photosensitive resin layer over the conductive structure, a portion of the photosensitive resin layer having an aperture extending therethrough and exposing a portion of the conductive structure; and

forming an edge of a piezoelectric substrate on which the interdigital transducer electrode is disposed that is free from the photosensitive resin layer.

~~37.~~34. The method of claim ~~36~~ 33 wherein the forming the conductive structure includes depositing a seed layer over the cavity structure and plating the conductive structure onto the seed layer.

~~38.~~35. The method of claim ~~37~~ 34 wherein the forming the conductive structure further includes masking portions of the seed layer prior to plating the conductive structure onto the seed layer.

~~39.~~36. The method of claim ~~36~~ 33 wherein the conductive structure includes a gap extending through a portion thereof and exposing a portion of the cavity structure, and the photosensitive resin layer fills the gap.

~~40.~~37. The method of claim ~~36~~ 33 further comprising forming a conductive terminal extending through ~~an~~ the aperture in the photosensitive resin layer and in electrical communication with the conductive structure.

~~41. A packaged surface acoustic wave device comprising:~~

~~a piezoelectric substrate having a first side and a second side;~~

~~an interdigital transducer electrode encapsulated within a package structure and supported by the first side of the piezoelectric substrate; and~~

~~a marking formed in the second side of the piezoelectric substrate.~~

~~42. The packaged surface acoustic wave device of claim 41 wherein the marking extends less than 1 micrometer into the second side of the piezoelectric substrate.~~

~~43. The packaged surface acoustic wave device of claim 41 wherein the marking extends less into less than 1% of a thickness of the piezoelectric substrate.~~

~~44. The packaged surface acoustic wave device of claim 41 wherein the marking is formed by a laser.~~

~~45. The packaged surface acoustic wave device of claim 41 wherein the piezoelectric substrate includes lithium niobate.~~

~~46. The packaged surface acoustic wave device of claim 41 wherein the piezoelectric substrate includes lithium tantalite.~~

~~47. The packaged surface acoustic wave device of claim 41 wherein the package structure includes a cavity structure encapsulating the interdigital transducer electrode and an outer coat including a photosensitive resin.~~

~~48. The packaged surface acoustic wave device of claim 41 wherein a total thickness of the packaged surface acoustic wave device is less than 220 micrometers.~~

~~49. The packaged surface acoustic wave device of claim 41 wherein the package structure includes a photosensitive resin buffer coat.~~

~~50. The packaged surface acoustic wave device of claim 49 wherein the photosensitive resin buffer coat includes phenol resin.~~

~~51. The packaged surface acoustic wave device of claim 49 wherein the photosensitive resin buffer coat includes a negative photoresist.~~

~~52. The packaged surface acoustic wave device of claim 49 further comprising a plurality of terminals extending through apertures in the photosensitive resin buffer coat.~~

~~53. A packaged surface acoustic wave device comprising:~~

~~a laser-marked piezoelectric substrate having a first side and a second side, the second side of the laser-marked piezoelectric substrate having a laser-marked section;~~

~~an interdigital transducer electrode supported by the first side of the laser-marked piezoelectric substrate, and~~

~~a structure supported by the first side of the laser-marked piezoelectric substrate defining a cavity enclosing the interdigital transducer electrode.~~

~~54. The packaged surface acoustic wave device of claim 53 wherein the laser-marked section has been exposed to a deep ultraviolet laser.~~

~~55. The packaged surface acoustic wave device of claim 53 wherein the laser-marked section includes laser markings extending less than 1 micrometer into the second side of the piezoelectric substrate.~~

~~56. The packaged surface acoustic wave device of claim 53 wherein the laser-marked piezoelectric substrate includes lithium niobate.~~

~~57. The packaged surface acoustic wave device of claim 53 wherein the laser-marked piezoelectric substrate includes lithium tantalite.~~

~~58. The packaged surface acoustic wave device of claim 53 wherein the package structure includes a photosensitive resin buffer coat.~~

~~59. The packaged surface acoustic wave device of claim 58 wherein the photosensitive resin buffer coat includes phenol resin.~~

~~60. The packaged surface acoustic wave device of claim 58 wherein the photosensitive resin buffer coat includes a negative photoresist.~~

~~61. A method of marking a packaged surface acoustic wave device, the method comprising:~~

grinding a back side of a piezoelectric substrate, the back side being opposite a front side of the piezoelectric substrate on which an interdigital transducer electrode of the surface acoustic wave device is disposed; and

laser marking the piezoelectric substrate.

62. The method of claim 61 wherein the laser marking forms a marking that extends less than 1 micron into the piezoelectric substrate.

63. The method of claim 61 wherein the laser marking includes applying a wavelength of laser light that allows the piezoelectric substrate to maintain structural integrity.

64. The method of claim 61 wherein the laser marking includes using a deep ultraviolet laser.

65. The method of claim 61 wherein the laser marking includes using a laser with a wavelength of about 266 nanometers.

66. The method of claim 61 wherein the grinding the back side of the piezoelectric substrate includes grinding the back side of the piezoelectric substrate until a thickness of the piezoelectric substrate is about 130 micrometers.

67. The method of claim 61 wherein the piezoelectric substrate includes lithium niobate.

68. The method of claim 61 wherein the piezoelectric substrate includes lithium tantalite.

69. The method of claim 61 further comprising forming a structure supported by the front side of the piezoelectric substrate and defining a cavity enclosing the interdigital transducer electrode.

70. The method of claim 69 wherein the structure supported by the front side of the piezoelectric substrate is formed before grinding the back side of the piezoelectric substrate.

71. The method of claim 69 wherein forming the structure supported by the front side of the piezoelectric substrate includes forming a photosensitive resin buffer coat.

72. A method of marking a packaged surface acoustic wave device, the method comprising:

forming a packaging structure on a first surface of a piezoelectric substrate on which an interdigital transducer electrode of the surface acoustic wave device is disposed, the packaging structure encapsulating the interdigital transducer electrode in a cavity; and

directly marking a second surface of the piezoelectric substrate to form a marked portion of the piezoelectric substrate.

73. The method of claim 72 wherein the directly marking the second surface of the piezoelectric substrate includes exposing the marked portion of the second surface of the piezoelectric substrate to laser light.

74. The method of claim 73 wherein the laser light includes deep ultraviolet light.

75. The method of claim 73 wherein the laser light has a wavelength of about 266 nanometers.

76. The method of claim 72 wherein the forming a packaging structure includes forming a layer of photosensitive resin and patterning the layer of photosensitive resin.

77. The method of claim 76 wherein the photosensitive resin includes a phenol resin.

78. The method of claim 76 wherein the forming a packaging structure includes forming a conductive terminal extending through the layer of photosensitive resin.

79. The method of claim 72 wherein the marking extends less than 1 micron into the piezoelectric substrate.

~~80. The method of claim 72 wherein the packaged surface acoustic wave device has a thickness of less than 220 micrometers.~~