CLAIMS

Claim 1: A piezoelectric thin film resonator comprising:

a substrate;

a piezoelectric film located on the substrate;

a lower electrode and an upper electrode facing each other across at least a part of the piezoelectric film; and

an insertion film that is inserted into the piezoelectric film, is located in at least a part of an outer periphery region in a resonance region in which the lower electrode and the upper electrode face each other across the piezoelectric film, and is not located in a center region of the resonance region,

wherein the insertion film is located from the at least a part of the outer periphery region to an outside of the resonance region,

wherein the insertion film is exposed from a side surface of the piezoelectric film.

Claim 2: The piezoelectric thin film resonator according to claim 1, wherein

the insertion film has a Young's modulus less than a Young's modulus of the piezoelectric film.

Claim 3: The piezoelectric thin film resonator according to claim 1, wherein the piezoelectric film is composed mainly of aluminum nitride.

Claim 4: The piezoelectric thin film resonator according to claim 3, wherein the insertion film is composed mainly of at least one of Al, Au, Cu, Ti, Pt, Ta, Cr, and silicon oxide.

Claim 5: The piezoelectric thin film resonator according to claim 1, wherein the insertion film is a metal film.

Claim 6: The piezoelectric thin film resonator according to claim 1, wherein

$T1/T2 \leq 0.2$

where T1 represents a film thickness of the insertion film and T2 represents a film thickness of a multilayered film in the center region.

Claim 7: The piezoelectric thin film resonator according to claim 1, wherein a width of the insertion film in the resonance region of the insertion film is equal to or less than 2.5 times a wavelength of an acoustic wave in a thickness extension mode of the piezoelectric thin film resonator.

Claim 8: The piezoelectric thin film resonator according to claim 1, wherein

a width of the insertion film in the resonance region of the insertion film is equal to or less than 1.5 times a wavelength of an acoustic wave in a thickness extension mode of the piezoelectric thin film resonator.

Claim 9: The piezoelectric thin film resonator according to claim 1, wherein

an air-space is formed between the substrate and an insulating film making contact with the lower electrode or the lower electrode in the resonance region.

Claim 10: The piezoelectric thin film resonator according to claim 1, further comprising:

an acoustic reflection film reflecting an acoustic wave propagating through the piezoelectric film under the lower electrode in the resonance region.

Claim 11: The piezoelectric thin film resonator according to claim 1, wherein

a side surface of the insertion film is tapered so that an upper surface of the insertion film is smaller than a bottom surface thereof.

Claim 12: The piezoelectric thin film resonator according to claim 11, wherein

an angle between the bottom surface of the insertion film and the side surface thereof is 60° or less.

Claim 13: A filter comprising:

a piezoelectric thin film resonator according to claim 1.

Claim 14: A duplexer comprising:

a transmit filter; and

a receive filter, wherein

at least one the transmit filter and the receive filter is a filter according to claim 13.

Claim 15: A piezoelectric thin film resonator comprising:

a substrate;

a piezoelectric film located on the substrate;

a lower electrode and an upper electrode facing each other across at least a part of the piezoelectric film; and

an insertion film that is inserted into the piezoelectric film, is located in at least a part of an outer periphery region in a resonance region in which the lower electrode and the upper electrode face each other across the piezoelectric film, and is not located in a center region of the resonance region,

wherein the insertion film is not located in a region other than the resonance region.

Claim 16: A piezoelectric thin film resonator comprising:

a substrate;

a piezoelectric film located on the substrate;

a lower electrode and an upper electrode facing each other across at least a part of the piezoelectric film; and

an insertion film that is inserted into the piezoelectric film, is located in at least a part of an outer periphery region in a resonance region in which the lower electrode and the upper electrode face each other across the piezoelectric film, and is not located in a center region of the resonance region,

wherein a slit from the center region of the resonance region to an outside of the resonance region is formed in the insertion film.

Claim 17: A piezoelectric thin film resonator comprising:

a substrate;

a piezoelectric film located on the substrate;

a lower electrode and an upper electrode facing each other across at least a part of the piezoelectric film; and

an insertion film that is inserted into the piezoelectric film, is located in a part of an outer periphery region in a resonance region in which the lower electrode and the upper electrode face each other across the piezoelectric film, and is not located in a center region of the resonance region,

wherein a width of the insertion film in a region other than the resonance region is larger than a width of the insertion film in the resonance region.

Claim 18: A filter comprising a plurality of piezoelectric thin film resonators, each of the plurality of piezoelectric thin film resonators comprising:

a substrate;

a piezoelectric film located on the substrate;

a lower electrode and an upper electrode facing each other across at least a part of the piezoelectric film; and

an insertion film that is inserted into the piezoelectric film, is located in a part of an outer periphery region in a resonance region in which the lower electrode and the upper electrode face each other across the piezoelectric film, and is not located in a center region of the resonance region,

wherein the plurality of piezoelectric thin film resonators share a single insertion film as the insertion film.

CLAIMS

What is claimed is:

1. A piezoelectric thin film resonator comprising:

a substrate;

a piezoelectric film located on the substrate;

a lower electrode and an upper electrode facing each other across at least a part of the piezoelectric film; and

an insertion film that is inserted into the piezoelectric film, is located in at least a part of an outer periphery region in a resonance region in which the lower electrode and the upper electrode face each other across the piezoelectric film, and is not located in a center region of the resonance region.

2. The piezoelectric thin film resonator according to claim 1, wherein

the insertion film is located from the at least a part of the outer periphery region to an outside of the resonance region.

3. The piezoelectric thin film resonator according to claim 1 or 2, wherein

the insertion film has a Young's modulus less than a Young's modulus of the piezoelectric film.

4. The piezoelectric thin film resonator according to any one of claims 1 through

3, wherein

the piezoelectric film is composed mainly of aluminum nitride.

5. The piezoelectric thin film resonator according to claim 4, wherein

the insertion film is composed mainly of at least one of Al, Au, Cu, Ti, Pt, Ta, Cr, and silicon oxide.

6. The piezoelectric thin film resonator according to any one of claims 1 through 4, wherein

the insertion film is a metal film.

7. The piezoelectric thin film resonator according to any one of claims 1 through 6, wherein

$T1/T2 \leq 0.2$

where T1 represents a film thickness of the insertion film and T2 represents a film thickness of a multilayered film in the center region.

8. The piezoelectric thin film resonator according to any one of claims 1 through 7, wherein

a width of the insertion film in the resonance region of the insertion film is equal to or less than 2.5 times a wavelength of an acoustic wave in a thickness extension mode of the piezoelectric thin film resonator.

9. The piezoelectric thin film resonator according to any one of claims 1 through 7, wherein

a width of the insertion film in the resonance region of the insertion film is equal to or less than 1.5 times a wavelength of an acoustic wave in a thickness extension mode of the piezoelectric thin film resonator.

10. The piezoelectric thin film resonator according to any one of claims 1 through 9, wherein

an air-space is formed between the substrate and an insulating film making contact with the lower electrode or the lower electrode in the resonance region.

11. The piezoelectric thin film resonator according to any one of claims 1 through 9, further comprising:

an acoustic reflection film reflecting an acoustic wave propagating through the piezoelectric film under the lower electrode in the resonance region.

12. The piezoelectric thin film resonator according to any one of claims 1 through 11, wherein

a side surface of the insertion film is tapered so that an upper surface of the insertion film is smaller than a bottom surface thereof.

13. The piezoelectric thin film resonator according to claim 12, wherein

an angle between the bottom surface of the insertion film and the side surface thereof is

60° or less.

14. A filter comprising:

a piezoelectric thin film resonator according to any one of claims 1 through 13.

15. A duplexer comprising:

a transmit filter; and

a receive filter, wherein

at least one the transmit filter and the receive filter is a filter according to claim 14.