Claims

1. An acoustic wave device using a surface acoustic wave, comprising:

a substrate containing 70 mass% or greater of silicon dioxide (SiO_2);

a piezoelectric thin film formed of $LiTaO_3$ crystal, the piezoelectric thin film being disposed on the substrate, the piezoelectric thin film including $LiTaO_3$ crystal and having Euler angles of (90°±5°, 90°±5°, 33°-55°), (90°±5°, 90°±5°, 125°-155°), or crystallographically equivalent Euler angles thereof; and

an interdigital transducer electrode disposed in contact with the piezoelectric thin film.

2. The acoustic wave device of claim 1 further comprising a shunt electrode and/or an insulating boundary film between the substrate and the piezoelectric thin film.

3. The acoustic wave device of claim 1 or 2 wherein a phase velocity of the surface acoustic wave propagating along the substrate is configured to be greater than a phase velocity of the surface acoustic wave propagating along the piezoelectric thin film.

4. The acoustic wave device of any one of claims 1 to 3 wherein the interdigital transducer electrode is disposed for at least lower portion to be embedded in the piezoelectric thin film and/or at least upper portion to be protruded from the piezoelectric thin film.

5. The acoustic wave device of any one of claims 1 to 4 wherein the substrate includes a quartz substrate.

6. The acoustic wave device of any one of claims 1 to 5 wherein the substrate has a shear wave phase velocity of a bulk wave of 3,400 to 4,800 m/s.

7. The acoustic wave device of any one of claims 1 to 4 and 6 wherein the substrate includes an isotropic substrate, the piezoelectric thin film having a thickness of 0.001 mm or greater and less than 0.01 mm.

8. The acoustic wave device of any one of claims 1 to 7 wherein the substrate includes a quartz substrate and a phase velocity of the surface acoustic wave to propagate is 4,500 m/s or greater.

9. The acoustic wave device of any one of claims 1 to 7 wherein the substrate includes a quartz substrate and a phase velocity of the surface acoustic wave to propagate is 4,800 m/s or greater.

10. The acoustic wave device of any one of claims 1 to 7 wherein the substrate includes a quartz substrate and a phase velocity of the surface acoustic wave to propagate is 5,000 m/s or greater.

11. The acoustic wave device of any one of claims 1 to 10 wherein the substrate includes a quartz substrate, the surface acoustic wave to propagate being a leaky acoustic wave including primarily a SH component or an S wave having a phase velocity of 4,500 m/s or greater.

~~12. The acoustic wave device of claim 1 further comprising Si containing film disposed between the substrate and the piezoelectric thin film, the Si containing film containing 30% or greater of SiO_2 or SiO, the substrate having a shear wave phase velocity of a bulk wave of 5,900 m/s or greater, and the Si containing film having a thickness of 0.15 times to 1 times a wavelength of the surface acoustic wave.~~

~~13. The acoustic wave device of claim 1 further comprising Si containing film disposed between the substrate and the piezoelectric thin film, the Si containing film containing 30% or greater of SiO_2 or SiO, the substrate having a shear wave phase velocity of a bulk wave of 5,900 m/s or greater, and the Si containing film having a thickness of 0.3 times to 0.5 times a wavelength of the surface acoustic wave.~~

12~~14~~. The acoustic wave device of claim 1 wherein the interdigital transducer electrode has a thickness indicated in Table 1 depending on a density thereof.

Table 1

Density range (kg/m^3)	Electrode thickness [wavelength (λ)]

2000-5000	0.005-0.32
5001-9500	0.005-0.20
9501-15000	0.005-0.28
15001-220000	0.005-0.20

13~~15~~. The acoustic wave device of claim 1 wherein the interdigital transducer electrode has a metalization ratio indicated in Table 2 depending on a density thereof.

Table 2

Density range (kg/m^3)	Electrode metalization ratio
2000-5000	0.15-0.63
5001-9500	0.15-0.63
9501-15000	0.15-0.71
15001-220000	0.15-0.65

14~~16~~. The acoustic wave device of claim 1 further comprising an insulating boundary film disposed between the substrate and the piezoelectric thin film, the boundary film having a thickness of 0.34 wavelength or greater.

15~~17~~. The acoustic wave device of claim 1 wherein the surface acoustic wave is a longitudinal-wave-type leaky surface acoustic wave.