CLAIMS

What is claimed is:

~~1. A method for manufacturing a piezoelectric film, the method comprising:~~

~~a coating step of obtaining a coated film by coating a coating solution on a substrate, wherein the coating solution includes at least lead, zirconium, and titanium, a content ratio of the zirconium and the titanium is in a range of 54:46 to 40:60 in terms of molar ratio, and a perovskite crystal phase is generated by heating the coating solution at a temperature equal to or higher than a crystallization initiation temperature;~~

~~a drying step of obtaining a dried film by drying the coated film;~~

~~a first calcining step of obtaining a first calcined film by heating the dried film at a first calcining temperature in a range of equal to or higher than the crystallization initiation temperature and equal to or lower than a temperature of the crystallization initiation temperature + 40°C;~~

~~a second calcining step of obtaining a second calcined film by heating the first calcined film at a second calcining temperature which is equal to or higher than a temperature of the first calcining temperature + 25°C and in a range of equal to or higher than a temperature of the crystallization initiation temperature + 25°C and equal to or lower than a temperature of the crystallization initiation temperature + 100°C; and~~

~~a main firing step of obtaining a piezoelectric film by heating the second calcined film at a main firing temperature which is equal to or higher than a temperature of the second calcining temperature + 25°C and in a range of equal to or higher than a temperature of the crystallization initiation temperature + 100°C and equal to or lower than a temperature of the crystallization initiation temperature + 200°C.~~

~~2. The method for manufacturing a piezoelectric film according to Claim 1,~~

~~wherein the coating step, the drying step, and the first calcining step are repeatedly performed before the second calcining step.~~

~~3. The method for manufacturing a piezoelectric film according to Claim 1 or 2,~~

~~wherein the coating solution contains an organic substance, and~~

~~the method further comprises an organic substance removing step of removing the organic substance included in the dried film by heating the dried film after the drying step and before the first calcining step.~~

~~4. The method for manufacturing a piezoelectric film according to any one of Claims 1 to 3,~~

~~wherein a content ratio of the zirconium and the titanium in the coating solution is in a range of 50:50 to 40:60 in terms of molar ratio.~~

~~5~~1. A piezoelectric film comprising:

a tetragonal perovskite crystal including at least lead, zirconium, and titanium,

wherein the tetragonal perovskite crystal has a ratio of a length of a c-axis to a length of an a-axis in a range of 1.0071 or more and 1.0204 or less, and, when a linear analysis of concentrations of zirconia and titanium in a thickness direction is carried out, a difference between a lowest value and a highest value of a molar ratio of the concentration of titanium to the concentration of zirconia is more than 0.1 and 0.45 or less.

~~6~~2. The piezoelectric film according to Claim ~~5~~1,

wherein, in an X-ray diffraction pattern measured using a Cu-Kα line, a half width of a diffraction peak derived from a (400) plane of the tetragonal perovskite crystal

is 1.40 degrees or less in terms of a diffraction angle of 2θ.

~~7~~3. The piezoelectric film according to Claim ~~5~~ 1 or ~~6~~2,

wherein a film thickness is in a range of 0.5 μm or more and 5 μm or less.

~~8~~4. A piezoelectric element comprising:

a piezoelectric layer; and

an electrode layer formed on a surface of the piezoelectric layer,

wherein the piezoelectric layer includes the piezoelectric film according to any one of Claims ~~5~~ 1 to ~~7~~3.

5. (New) A method for manufacturing the piezoelectric film according to any one of Claims 1 to 3, the method comprising:

a coating step of obtaining a coated film by coating a coating solution on a substrate, wherein the coating solution includes at least lead, zirconium, and titanium, a content ratio of the zirconium and the titanium is in a range of 54:46 to 40:60 in terms of molar ratio, and a perovskite crystal phase is generated by heating the coating solution at a temperature equal to or higher than a crystallization initiation temperature;

a drying step of obtaining a dried film by drying the coated film;

a first calcining step of obtaining a first calcined film by heating the dried film at a first calcining temperature in a range of equal to or higher than the crystallization initiation temperature and equal to or lower than a temperature of the crystallization initiation temperature + 40°C;

a second calcining step of obtaining a second calcined film by heating the first calcined film at a second calcining temperature which is equal to or higher than a

temperature of the first calcining temperature + 25°C and in a range of equal to or higher than a temperature of the crystallization initiation temperature + 25°C and equal to or lower than a temperature of the crystallization initiation temperature + 100°C; and

a main firing step of obtaining a piezoelectric film by heating the second calcined film at a main firing temperature which is equal to or higher than a temperature of the second calcining temperature + 25°C and in a range of equal to or higher than a temperature of the crystallization initiation temperature + 100°C and equal to or lower than a temperature of the crystallization initiation temperature + 200°C.

6. (New) The method for manufacturing a piezoelectric film according to Claim 5,

wherein the coating step, the drying step, and the first calcining step are repeatedly performed before the second calcining step.

7. (New) The method for manufacturing a piezoelectric film according to Claim 5 or 6,

wherein the coating solution contains an organic substance, and

the method further comprises an organic substance removing step of removing the organic substance included in the dried film by heating the dried film after the drying step and before the first calcining step.

8. (New) The method for manufacturing a piezoelectric film according to any one of Claims 5 to 7,

wherein a content ratio of the zirconium and the titanium in the coating solution is in a range of 50:50 to 40:60 in terms of molar ratio.