CLAIMS

What is claimed is:

1. A piezoelectric thin-film resonator comprising:

a lower electrode provided on a substrate;

a piezoelectric film that is provided on the lower electrode and includes at least two layers;

an upper electrode that is provided on the piezoelectric film and has a region sandwiching the piezoelectric film with the lower electrode and facing the lower electrode; and

an insulating film that is provided under said region of the upper electrode between the at least two layers and that is in direct contact with each of the at least two layers,

wherein an upper face of the insulating film is flatter than a lower face of the insulating film.

2. The piezoelectric thin-film resonator as claimed in claim 1, wherein an RMS value of the upper face of the insulating film is smaller than an RMS value of the lower face of the insulating film by 30 % or more.

3. The piezoelectric thin-film resonator as claimed in claim 1, wherein:

the piezoelectric film has a structure of two layers; and

the insulating film is a single layer provided between the two layers of the piezoelectric film.

4. The piezoelectric thin-film resonator as claimed in claim 1, wherein the insulating

film is an insulating film of which main component is silicon oxide.

5. The piezoelectric thin-film resonator as claimed in claim 1, wherein the piezoelectric film is aluminum nitride or another aluminum nitride in which an impurity is doped.

6. A method for manufacturing a piezoelectric thin-film resonator comprising:

forming a lower electrode on a substrate;

depositing a first piezoelectric film on the lower electrode;

depositing an insulating film on the first piezoelectric film;

flattening an upper face of the insulating film;

depositing a second piezoelectric film on the insulating film of which upper face is flattened; and

forming an upper electrode on the second piezoelectric film so as to have a region sandwiching the first piezoelectric film, the insulating film and the second piezoelectric film with the lower electrode and facing the lower electrode.

7. The method as claimed in claim 6, wherein the forming of the first piezoelectric film, the forming of the insulating film, the flattening of the upper face of the insulating film and the forming of the second piezoelectric film are performed in series in a single vacuum equipment without breaking vacuum.

8. The method as claimed in claim 6, wherein the flattening of the upper face of the insulating film is performed with use of inert gas plasma.

9. The method as claimed in claim 6 further comprising flattening an upper face of the first piezoelectric film,

wherein the forming of the insulating film includes forming the insulating film on the first piezoelectric film of which upper face is flattened.

10. The piezoelectric thin-film resonators as claimed in claim 1,

wherein the insulating film has an elastic constant of a temperature coefficient of which sign is opposite to a sign of a temperature coefficient of an elastic constant of the piezoelectric film.

11. The method as claimed in claim 6, wherein the first piezoelectric film, the insulating film and the second piezoelectric film are deposited by sputtering.

CLAIMS

What is claimed is:

1. A piezoelectric thin-film resonator comprising:

a lower electrode provided on a substrate;

a piezoelectric film that is provided on the lower electrode and includes at least two layers;

an upper electrode that is provided on the piezoelectric film and has a region sandwiching the piezoelectric film with the lower electrode and facing the lower electrode; and

an insulating film that is provided in a region in which the lower electrode and the upper electrode face each other and between each of the at least two layers,

wherein an upper face of the insulating film is flatter than a lower face of the insulating film.

2. The piezoelectric thin-film resonator as claimed in claim 1, wherein an RMS value of the upper face of the insulating film is smaller than an RMS value of the lower face of the insulating film by 30 % or more.

3. The piezoelectric thin-film resonator as claimed in claim 1 or 2, wherein:

the piezoelectric film has a structure of two layers; and

the insulating film is a single layer provided between the two layers of the insulating film.

4. The piezoelectric thin-film resonator as claimed in any of claims 1 to 3, wherein the insulating film is an insulating film of which main component is silicon oxide.

5. The piezoelectric thin-film resonator as claimed in any of claims 1 to 4, wherein the piezoelectric film is aluminum nitride or another aluminum nitride in which an impurity is doped.

6. A method for manufacturing a piezoelectric thin-film resonator comprising:

forming a lower electrode on a substrate;

forming a first piezoelectric film on the lower electrode;

forming an insulating film on the first piezoelectric film;

flattening an upper face of the insulating film;

forming a second piezoelectric film on the insulating film of which upper face is flattened; and

forming an upper electrode on the second piezoelectric film so as to have a region sandwiching the first piezoelectric film, the insulating film and the second piezoelectric film with the lower electrode and facing the lower electrode.

7. The method as claimed in claim 6, wherein the forming of the first piezoelectric film, the forming of the insulating film, the flattening of the upper face of the insulating film and the forming of the second piezoelectric film are performed in series in a single vacuum equipment without breaking vacuum.

8. The method as claimed in claim 6 or 7, wherein the flattening of the upper face of the insulating film is performed with use of inert gas plasma.

9. The method as claimed in any of claims 6 to 8 further comprising flattening an upper face of the first piezoelectric film,

wherein the forming of the insulating film includes forming the insulating film on the first piezoelectric film of which upper face is flattened.