dopant in the n-type Si layer 11 in the vibrating device 1.

[0038]

The rotation angle as an abscissa of Figure 10 represents the relationship between a longitudinal direction of the vibrating arms 3a to 3c and a direction of an Si crystal axis in the n-type Si layer 11. For example, in the case of Si (100), the rotation angle is 0 degrees. In the case of Si (110), the rotation angle is 45 degrees. In the case of Si (010) =Si (100), the rotation angle is 90 degrees. More specifically, 90 degrees in the case of Si (010) is equivalent to 0 degrees in the case of Si (100).

[0039]

Figure 11 illustrates the relationship between temperature, a ratio of change in resonance frequency $\Delta Fr$, and the doping concentration of the n-type dopant in the n-type Si layer 11 in the vibrating device 1. Figure 11 illustrates a result when the rotation angle is 0 degrees.

[0040]

Figures 10 and 11 illustrate the cases where the doping concentration of the n-type dopant is set to $5\times10^{19}/cm^3$ and $1\times10^{19}/cm^3$ in the vibrating device 1 of the present embodiment. Figures 10 and 11 also illustrate the case of a comparative example 1 similar in configuration to the vibrating device 1 of the present embodiment except for the point that the doping

Claims

[Claim 1]

A vibrating device, comprising:

a supporter; and

a vibrating arm connected to the supporter, wherein

the vibrating arm has an n-type Si layer which is a degenerated semiconductor and an exciter provided on the n-type Si layer, and

the exciter has a piezoelectric thin film, and first and second electrodes provided with the piezoelectric thin film interposed therebetween, the exciter causing bending vibration of the vibrating arm.

[Claim 2]

A vibrating device, comprising:

a supporter; and

a vibrating arm connected to the supporter, wherein

the vibrating arm has an n-type Si layer having a doping concentration of $1\times10^{19}/cm^3$ or more, and an exciter provided on the n-type Si layer, and

the exciter has a piezoelectric thin film, and first and second electrodes with the piezoelectric thin film interposed therebetween, the exciter causing bending vibration of the vibrating arm.

[Claim 3]

The vibrating device according to claim 1 or 2, wherein

the vibrating arms are provided in an odd number, and

the exciter is configured to cause out-of-plane bending vibration of the vibrating arms.

[Claim 4]

The vibrating device according to claim 1 or 2, wherein

the vibrating arms are provided in an even number, and

the exciter is configured to cause in-plane bending vibration of the vibrating arms.

[Claim 5]

The vibrating device according to any one of claims 1 to 4, wherein

the vibrating arm has a mass addition unit provided in an end portion opposite to an end portion connected to the supporter.

[Claim 6]

The vibrating device according to any one of claims 1 to 5, wherein

a silicon oxide film is placed between the n-type Si layer and the exciter.

[Claim 7]

The vibrating device according to claim 6, wherein

the silicon oxide film is formed by a thermal oxidation method.

[Claim 8]

A method for manufacturing the vibrating device according to any one of claims 1 to 7, comprising the steps of:

preparing an n-type Si layer connected to a supporter;

forming a first electrode on the n-type Si layer;

forming a piezoelectric thin film on the first electrode; and

constituting a second electrode on the piezoelectric thin film.

[Claim 9]

The method for manufacturing the vibrating device according to claim 8, wherein

the step of preparing the structure in which the n-type Si layer is connected to the supporter includes the steps of:

preparing a support substrate made of Si and having a recess portion on one surface thereof; and

laminating an n-type Si layer over the recess portion of the support substrate.

dopant in the n-type Si layer 11 in the vibrating device 1.

[0038]

The rotation angle as an abscissa of Figure 10 represents the relationship between a longitudinal direction of the vibrating arms 3a to 3c and a direction of an Si crystal axis in the n-type Si layer 11. For example, in the case of Si[100], the rotation angle is 0 degrees. In the case of Si[110], the rotation angle is 45 degrees. In the case of Si[010]=Si[100], the rotation angle is 90 degrees. More specifically, 90 degrees in the case of Si[010] is equivalent to 0 degrees in the case of Si[100].

[0039]

Figure 11 illustrates the relationship between temperature, a ratio of change in resonance frequency $\Delta Fr$, and the doping concentration of the n-type dopant in the n-type Si layer 11 in the vibrating device 1. Figure 11 illustrates a result when the rotation angle is 0 degrees.

[0040]

Figures 10 and 11 illustrate the cases where the doping concentration of the n-type dopant is set to $5\times10^{19}/cm^3$ and $1\times10^{19}/cm^3$ in the vibrating device 1 of the present embodiment. Figures 10 and 11 also illustrate the case of a comparative example 1 similar in configuration to the vibrating device 1 of the present embodiment except for the point that the doping

# Claims

1. A vibrating device, comprising:

a supporter; and

a vibrating arm connected to the supporter, wherein the vibrating arm has an n-type Si layer which is a degenerated semiconductor, and

an exciter provided on the n-type Si layer, and the exciter has a piezoelectric thin film, and first and second electrodes provided with the piezoelectric thin film interposed therebetween, the exciter causing bending vibration of the vibrating arm wherein a rotation angle between a longitudinal direction of the vibrating arm and a direction of a Si crystal axis defined by the Miller indices [100] is in a range of either:

a) 0 to 15 degrees; or

b) 75 to 90 degrees.

2. A vibrating device, comprising:

a supporter; and

a vibrating arm connected to the supporter, wherein the vibrating arm has an n-type Si layer having a doping concentration of $1\times10^{19}/cm^3$ or more, and

an exciter provided on the n-type Si layer, and the exciter has a piezoelectric thin film, and first and second electrodes with the piezoelectric thin film interposed therebetween, the exciter causing bending vibration of the vibrating arm wherein a rotation angle between a longitudinal direction of the vibrating arm and a direction of a Si crystal axis defined by the Miller indices [100] is in a range of either:

a) 0 to 15 degrees; or

b) 75 to 90 degrees.

3. The vibrating device according to claim 1 or claim 2,

wherein the vibrating arms are provided in an odd number, and the exciter is configured to cause out-of-plane bending vibration of the vibrating arms.

4. The vibrating device according to claim 1 or claim 2, wherein the vibrating arms are provided in an even number, and

the exciter is configured to cause in-plane bending vibration of the vibrating arms.

5. The vibrating device according to any one of claims 1 to 4, wherein the vibrating arm has a mass addition unit provided in an end portion opposite to an end portion connected to the supporter.

6. The vibrating device according to any one of claims 1 to 5, wherein a silicon oxide film is placed between the n-type Si layer and the exciter.

7. The vibrating device according to claim 6, wherein the silicon oxide film is formed by a thermal oxidation method.

8. A method for manufacturing the vibrating device according to any one of claims 1 to 7, comprising the steps of:

preparing an n-type Si layer connected to a supporter;

forming a first electrode on the n-type Si layer;

forming a piezoelectric thin film on the first electrode; and

constituting a second electrode on the piezoelectric thin film.

9. The method for manufacturing the vibrating device according to claim 8, wherein the step of preparing the

structure in which the n-type Si layer is connected to the supporter includes the steps of:

preparing a support substrate made of Si and having a recess portion on one surface thereof; and

laminating an n-type Si layer over the recess portion of the support substrate.