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REPLACED SHEETS SG

- ☑ Description : paged 1 to paged 128
- ☑ Claim(s) : paged 129 to paged 157
- ☑ Drawing(s) : paged 1 to paged 7
- ☑ Abstract : paged 158 to paged 158

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SEMICONDUCTOR MEMBER AND PROCESS FOR PREPARING SEMICONDUCTOR MEMBER

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Semiconductor Member and Process for Preparing Semiconductor Member

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a semiconductor member and a process for preparing a semiconductor member, more particularly to a semiconductor which is suitable for separation of dielectric materials or electronic devices, integrated circuits prepared on a monocrystalline semiconductor layer on an insulating material.

Related Background Art

Formation of a monocrystalline Si semiconductor layer on an insulating material has been widely known as the silicon on insulator (SOI) technology, and since a large number of advantages which can not be reached by bulk Si substrates for preparation of conventional Si integrated circuits are possessed by the device utilizing the SOI structure, so many researches have been done. More specifically, by utilizing the SOI structure, the following advantages can be obtained:

1. Dielectric isolation can be easily done to enable high degree of integration;

2. Radiation hardness is excellent;

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3. Stray capacity is reduced to attain high speed;

4. Well formation step can be omitted;

5. Latch-up can be prevented;

6. Fully depleted field effect transistor can be made by thin film formation.

In order to realize the many advantages in device characteristics as mentioned above, studies have been made about the method for forming the SOI structure for these some 10 years. The contents are summarized in, for example, the literature as mentioned below:

Special Issue: "Single-crystal silicon on non-single-crystal insulators"; edited by G.W. Cullen, Journal of Cryatal Growth, volume 63, No.3, pp. 429 - 590 (1983).

Also, it has been known for a long time to form the SOS (silicon on sapphire) structure by heteroepitaxy of Si on a monocrystalline sapphire substrate by CVD (chemical vapor deposition) method. This was successful to some extent as the most mature SOI technique, but for such reasons as a large amount of crystal defects because of lattice mismatching at the interface between the Si layer and the sapphire substrate, introduction of aluminum from the sapphire substrate into the Si layer, and above all the high

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cost of the substrate and delay in enlargement of the substrate wafer size, it is obstructed from being widely applied. Relatively in recent years, attempts to realize the SOI structure without use of a sapphire substrate have been done. Such attempts may be broadly classified into the three shown below.

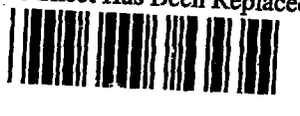
(1) After surface oxidation of a Si monocrystalline substrate, a window is formed to have the Si substrate partially exposed, and epitaxial growth is proceeded in the lateral direction with that exposed portion as the seed to form an Si monocrystalline layer on SiO_2. (In this case, deposition of Si layer on SiO_2 is accompanied).

(2) By use of a Si monocrystalline substrate itself as active layer, SiO_2 is formed therebeneath. (This method is accompanied with no deposition of Si layer).

(3) After epitaxial growth of Si on a Si monocrystalline substrate, isolation separation is effected. (This method is accompanied with deposition of Si layer).

As the means for realizing the above (1), there have been known the method in which a monocrystalline Si layer is formed directly to lateral epitaxial growth by CVD, the method in which amorphous Si is deposited and subjected to solid phase lateral

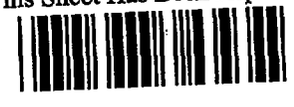
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epitaxial growth by heat treatment, the method in which amorphous or polycrystalline Si layer is irradiated convergently with an energy beam such as electron beam, laser beam, etc. and a monocrystalline layer is grown on SiO_2 by melting and recrystallization, and the method in which a melting region is scanned in a zone fashion by a rod-shaped heater (Zone melting recrystallization). These methods have both advantages and disadvantages, the still have many problems with respect to controllability, productivity, uniformity and quality, and none of them have been industrially applied yet up to date. For example, the CVD method requires sacrifice-oxidation in flat thin film formation, while the crystallinity is poor in the solid phase growth method. On the other hand, in the beam annealing method, problems are involved in controllability such as treatment time by converged beam scanning, the manner of overlapping of beams, focus adjustment, etc. Among these, the Zone Melting Recrystallization method is the most mature, and a relatively larger scale integrated circuit has been trially made, but still a large number of crystal defects such as point defect, line defect, plane defect (sub-boundary), etc. remain, and no device driven by minority carriers has been prepared.

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Concerning the method using no Si substrate as the seed for epitaxial growth which is the above method (2), for example, the following methods may be included.

1. An oxide film is formed on an Si monocrystalline substrate with V-grooves as anisotropically etched on the surface, a polycrystalline Si layer is deposited on the oxide film thick to the extent as the Si substrate, and thereafter by polishing from the back surface of the Si substrate, Si monocrystalline regions dielectrically separated by surrounding with the V-grooves on the thick polycrystalline Si layer are formed. In this method, although crystallinity is good, there are problems with respect to controllability and productivity in the step of depositing the polycrystalline Si thick as some hundred microns and the step in which the monocrystalline Si substrate is polished from the back surface to leave only the Si active layer as separated.

2. This is the method called SIMOX (Separation by ion-implanted oxygen) in which an SiO_2 layer is formed by ion implantation of oxygen into an Si monocrystalline substrate, which is one of the most mature methods because of good matching with the Si-IC

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(Integrated Circuit) process. However, for formation of the SiO_2 layer, 10^{18} ions/cm^2 or more of oxygen ions are required to be implanted, and the implantation time is very long to be not high in productivity, and also the wafer cost is high. Further, many crystal defects remin, and from an industrial point of view, no sufficient level of quality capable of preparing a device driven by minority carriers has been attained.

3. This is the method to form an SOI structure by dielectric isolation according to oxidation of porous Si. This is a method in which an N-type Si layer is formed on the surface of a P-type Si monocrystalline substrate in shape of islands by way of proton ion implantation (Imai et al., J. Crystal Growth, Vol. 63,547 (1983)), or by epitaxial growth and patterning: only the p-type Si substrate is made porous by anodization in HF solution so as to surround the Si islands from the surface; and then the N-type Si islands are dielectrically isolated by accelerated oxidation. In this method, the separated Si region is determined before the device steps, whereby there is the problem that the degree of freedom in device and circuit design may be limited in some cases.

As the method (3) as described above, the

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method described in Japanese Laid-open Patent Application No. 56-16464 has the steps of forming an N-type monocrystalline Si layer on a P-type Si wafer, providing a glass layer containing an oxide of the N-type impurity thereon and the step of bonding the glass layer to a glass layer containing the oxide of an N-purity impurity provided on another silicon wafer by heat treatment. And, subsequent to the bonding step, the P-type Si wafer is made porous, and then the porous layer is oxidized, followed by etching to remove the porous layer, thereby forming an SOI structure. Also, Japanese Patent Publication No. 53-45675 discloses a method in which a silicon monocrystalline wafer is made porous, then oxidized to make the porous layer higher in resistance; a monocrystalline Si layer is formed on the porous silicon layer; and a part of the monocrystalline Si layer is made porous and higher in resistance so as to surround the monocrystalline Si region, thereby separating the monocrystalline Si region.

The methods described in these publications all include the step of oxidizing a porous layer, and because the volume of porous layer is increased by oxidation, sometimes an influence of distortion may be exerted on the monocrystalline Si layer, and therefore in these methods, a monocrystalline Si layer with

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constantly good quality could not necessarily be formed on the insulator.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a semiconductor member capable of overcoming the problems as described above and meeting the demands as described above and a process for preparing the member.

Another object of the present invention is to provide a semiconductor having a monocrystalline layer excellent in crystallinity equally as monocrystalline SOI wafer, and a process for preparing the member excellent also in aspects of productivity, uniformity, controllability, economy.

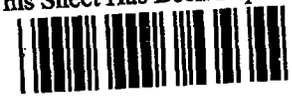
Still another object of the present invention is to provide a semiconductor member having excellent characteristics which can be sufficiently alternative for expensive SOS or SIMOX even in preparing a large scale integrated circuit by the SOI structure and a process for preparing the member economically.

Other objects of the present invention than those as mentioned above are:

to provide a process for preparing a semiconductor member comprising the steps of:

forming a member having a non-porous monocrystalline semiconductor region on a porous

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monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and then

removing the porous monocrystalline semiconductor region by chemical etching;

to provide a process for preparing a semiconductor member comprising the steps of:

forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on the non-porous monocrystalline semiconductor side of the member, then

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the porous monocrystalline semiconductor region by chemical etching;

to provide a process for preparing a semiconductor member comprising the steps of:

making a non-porous monocrystalline semiconductor member porous to form a porous monocrystalline semiconductor region,

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forming a non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and

removing the porous monocrystalline semiconductor region by chemical etching;

to provide a process for preparing a semiconductor member comprising the steps of:

making a non-porous monocrystalline semiconductor member porous to form a porous monocrystalline semiconductor region,

forming a non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

forming region constituted of an insulating substance on the non-porous monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the porous monocrystalline semiconductor region by chemical etching;

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to provide a process for preparing a semiconductor member comprising the steps of:

making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region,

forming a third non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the third non-porous monocrystalline semiconductor region, and

removing the second non-porous monocrystalline semiconductor region mechanically, and removing the porous monocrystalline semiconductor region by chemical etching;

to provide a process for preparing a semiconductor member comprising the steps of:

making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region,

forming a third non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

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forming a region constituted of an insulating substance on the third non-porous monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the second non-porous monocrystalline semiconductor mechanically, and removing the porous monocrystalline semiconductor region by chemical etching;

to provide a process for preparing a semiconductor member comprising the steps of:

forming a second monocrystalline semiconductor region of a second electroconduction type on a first monocrystalline semiconductor region of a first electroconduction type,

making the first monocrystalline semiconductor region porous to form a porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is formed of an insulating substance onto the surface of the second monocrystalline semiconductor region, and

removing the porous monocrystalline semiconductor region by chemical etching;

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to provide a process for preparing a semiconductor member comprising the steps of:

forming a second monocrystalline semiconductor region of a second electroconduction type on a first monocrystalline semiconductor region of a first electroconduction type,

making the first monocrystalline semiconductor region porous to form a porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on the second monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is formed of an insulating substance onto the surface of the second monocrystalline semiconductor region, and

removing the porous monocrystalline semiconductor region by chemical etching;

to provide a semiconductor member comprising:

a first member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region, and

a second member having the surface constituted of an insulating substance bonded onto the surface of the non-porous monocrystalline semiconductor region;

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to provide a semiconductor member comprising:

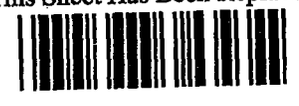
a first member having a non-porous monocrystalline semiconductor region and a region constituted of an insulating substance arranged in this order on a porous monocrystalline semiconductor region, and

a second member bonded through a region constituted of an insulating substance onto the surface of the region constituted of the insulating substance;

to provide a semiconductor member having a non-porous silicon monocrystalline semiconductor region arranged on a region constituted of an insulating substance, characterized in that the dislocation defect density in the non-porous silicon monocrystalline semiconductor region is $2.0 \times 10^4/cm^2$ or less, and the life time of carriers is 5.0×10^{-4} second or longer; and

to provide a semiconductor member having a non-porous silicon monocrystalline semiconductor region arranged on a region constituted of an insulating substance, characterized in that the dislocation defect density in the non-porous silicon monocrystalline semiconductor region is $2.0 \times 10^4/cm^2$ or less, and the life time of carriers is 5.0×10^{-4} sec or longer, and also the difference between the

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maximum value and the minimum value of the thickness of the silicon monocrystalline semiconductor region is 10% or less with respect to maximum value.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1 through 13 are schematic illustrations of the examples of the steps of the procesa for preparing the semiconductor member of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferable semiconductors of the present invention are as described below.

A semiconductor member of the present invention comprises:

a first member having a non-porous monocrystalline semiconductor region provided on a porous monocrystalline semiconductor region, and

a second member having the surface constituted of an insulating substance bonded onto the surface of the non-porous monocrystalline semiconductor region.

Another semiconductor member comprises:

a first member having a non-porous monocrystalline semiconductor region and a region constituted of an insulating substance arranged in this order on a porous monocrystalline semiconductor region, and

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a second member bonded through a region constituted of an insulating substance onto the surface of the region constituted of the insulating substance.

Still another semiconductor member has a non-porous silicon monocrystalline semiconductor region arranged on a region constituted of an insulating substance, wherein the dislocation defect density in the non-porous silicon monocrystalline semiconductor region is $2.0 \times 10^4/cm^2$ or less, and the life time of carriers is 5.0×10^{-4} sec or longer.

Still another semiconductor member has a non-porous silicon monocrystalline semiconductor region arranged on a region constituted of an insulating substance, wherein the dislocation defect density in the non-porous silicon monocrystalline semiconductor region is $2.0 \times 10^4/cm^2$ or less, and the life time of carriers is 5.0×10^{-4} sec or longer, and also the difference between the maximum value and the minimum value of the thickness of the silicon monocrystalline semiconductor region is 10% or less, with respect to the maximum value.

Preferable processes for preparing the semiconductor member of the present invention are as described below.

A process for preparing a semiconductor member

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of the present invention comprises:

forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and then

removing the porous monocrystalline semiconductor region by chemical etching.

Another process comprises:

forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

forming a region constituted of an insulting substance on the non-porous monocrystalline semiconductor side of the member, then

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the porous monocrystalline semiconductor region by chemical etching.

Still another process comprises:

making a non-porous monocrystalline semiconductor member porous to form a porous

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monocrystalline semiconductor region,

forming a non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and

removing the porous monocrystalline semiconductor region by chemical etching.

Still another process comprises the steps of:

making a non-porous monocrystalline semiconductor member porous to form a porous monocrystalline semiconductor region,

forming a non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on the non-porous monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the porous monocrystalline semiconductor region by chemical etching.

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Still another process comprises the steps of:

making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region,

forming a third non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the third non-porous monocrystalline semiconductor region, and

removing the second non-porous monocrystalline semiconductor region by mechanical grinding, and removing the porous monocrystalline semiconductor region by chemical etching.

Still another process comprises the steps of:

making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region,

forming a third non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on the third non-porous monocrystalline

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semiconductor region side,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the second non-porous monocrystalline semiconductor by mechanical grinding, and removing the porous monocrystalline semiconductor region by chemical etching.

Still another process comprises the steps of:

forming a second monocrystalline semiconductor region of a second conduction type on a first monocrystalline semiconductor region of a first conduction type,

making the first monocrystalline semiconductor region porous to form a porous monocrystalline semiconductor region,

forming a region constituted of an insulating material on the second monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the second monocrystalline semiconductor region, and

removing the porous monocrystalline semiconductor region by chemical etching.

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Still another process comprises the steps of:

forming a second monocrystalline semiconductor region of a second electroconduction type on a first monocrystalline semiconductor region of a first electroconduction type,

making the first monocrystalline semiconductor region porous to form a porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on the second monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is formed of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the porous monocrystalline semiconductor region by chemical etching.

The semiconductor member of the present invention has a monocrystalline semiconductor region where carrier life time is long and the defect is extremely little on an insulating material with excellent uniformity of thickness, and is applicable to various semiconductor devices. Also, the semiconductor member of the present invention is capable of high speed response, and is applicable to semiconductor devices rich in reliability. The

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semiconductor member of the present invention can be also an alternative for expensive SOS or SIMOX.

The process for preparing a semiconductor member of the present invention provides a process excellent in aspects of productivity, uniformity, controllability, economy in obtaining an Si crystal layer having crystallinity equal to monocrystalline wafer on an insulating material.

Further, according to the process for preparing a semiconductor member of the present invention, it is possible to provide semiconductor members wherein the advantages of the SOI device of the prior art can be realized and applied.

Also, according to the present invention, there can be provided a process for preparing a semiconductor member which can be an alternative for expensive SOS or SIMOX also in preparing a large scale integrated circuit of SOI structure.

The process for preparing a semiconductor member of the present invention, as is described in detail in Examples, makes it possible to perform the treatment efficiently within a short time, and is excellent in its productivity and economy.

Referring now to silicon as an example of semiconductor materials, the present invention is described in detail, but the semiconductor material in

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the present invention is not limited to silicon at all.

In porous Si layer, according to observation by transmission electron microscopy, pores with diameters of about 600 angstroms on an average are formed, and despite the fact that their density is half or lower as compared with monocrystalline silicon, monocrystallinity is maintained. Monocrystal refers to a crystalline solid such that, when calling attention on an optional crystal axis, its direction is the same at any part of the sample, and the porous layer used in the present invention, although having pores therethrough, the crystal axis in the crystalline region is the same in the direction at any part, thus being monocrystalline. And, epitaxial growth of a monocrystalline Si layer onto the porous layer is possible. However, at a temperature of 1000 ^{o}C or higher, rearrangement of the atoms positioned around the inner pores takes place, whereby the characteristics of accelerated chemical etching may be sometimes impaired. For this reason, in the present invention, for epitaxial growth of Si layer, there may be suitably used the crystal growth method capable of low temperature growth such as molecular beam epitaxial growth, plasma CVD, low pressure CVD method, photo CVD, bias-sputtering method, liquid phase growth

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method, etc.

Since the porous layer has a large amount of voids formed internally thereof, its density can be reduced to half or lower. As the result, the surface area per unit volume (specific surface area) can be dramatically increased, and therefore its chemical etching rate is remarkably accelerated as compared with that of the etching rate of conventional non-porous monocrystalline layer. The present invention utilizes the two above-mentioned characteristics of the semiconductor as made porous, namely the fact that single crystallinity is maintained and a non-porous semiconductor monocrystal can therefore be epitaxially grown on the semiconductor substrate as made porous, and the fact that etching rate is remarkably more rapid as compared with non-porous monocrystal, whereby a non-porous semiconductor monocrystalline layer of high quality can be formed on a substrate having an insulating material surface within a short time.

The porous layer can be more readily formed on a P-type Si layer than an N-type Si layer for the following reason. First, a porous Si was discovered by Uhlir et al. in the research process of electrolytic polishing of semiconductor in 1956 (A. Uhlir, Bell Syst. Tech. J., vol 35, p.333 (1956)).

Unagami et al. studied about the dissolving

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reaction of Si in anodization, and has reported that positive holes are necessary for the anodic reaction of Si in an HF solution, and the reaction is as follows (T. Unagami, J. Electrochem. Soc., vol. 127, p. 476 (1980)).

$$Si + 2HF + (2-n)e^{+} \longrightarrow SiF_2 + 2H^{+} + ne^{-}$$

$$SiF_2 + 2HF \longrightarrow SiF_4 + H_2$$

$$SiF_4 + 2HF \longrightarrow H_2SiF_6$$

or

$$Si + 4HF + (4 - \lambda)e^{+} \longrightarrow SiF_4 + 4H^{+} + \lambda e^{-}$$

$$SiF_4 + 2HF \longrightarrow H_2SiF_6.$$

Here, e^{+} and e^{-} represent a positive hole and an electron, respectively. n and λ are respectively numbers of positive holes necessary for dissolving one atom of silicon, and it has been postulated that porous silicon is formed when satisfying the condition of $n > 2$ or $\lambda > 4$.

For the reasons mentioned above, the P-type silicon in which positive holes exist will be more readily made porous than the N-type silicon of the opposite characteristic. Selectivity in such pore structure formation has been verified by Nagano et al. (Nagano, Nakajima, Yasuno, Ohnaka, Kajiwara; Denshi Tsushin Gakkai Gijutsu Kenkyu Hokoku, vol. 79, SSD 79-9549(1979)) and Imai, (K. Imai; Solid-State Electronics vol. 24, 159 (1981)). However, depending

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on the conditions, the N-type silicon can be also made porous.

Referring now to the drawings, the present invention is described in more detail.

Embodiment 1

Description is made about the process for obtaining a semiconductor substrate by making porous all of a P-type substrate and permitting a monocrystalline layer to be epitaxially grown.

As shown in Fig. 1A, first a P-type Si monocrystalline substrate is provided, and all of it is made porous. According to the crystal growth method capable of low temperature growth as mentioned above, epitaxial growth is effected on the substrate surface as made porous to form a thin film monocrystalline layer 22. The above P-type Si substrate is made porous by the anodization method by use of an HF solution. The porous Si layer 21 can be varied in its density to a range of 1.1 to 0.6 g/cm^3 by varying the HF solution concentration to 50 to 20% as compared with the deneity 2.33 g/cm^3 of the monocrystalline Si.

Subsequently, as shown in Fig. 1B, by providing another Si substrate 23 and after forming an oxidized layer 24 on its surface, the Si substrate 23 having the oxidized layer 24 on the surface is bonded

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onto the surface of the monocrystalline layer 22 on the porous Si substrate 21. Then, as shown in Fig. 1C, the porous Si substrate 21 is all etched away to form a thin film-like monocrystalline silicon layer 22 remaining on the SiO_2 layer 24. In the present invention, since the porous semiconductor layer is etched away without application of the oxidation treatment on the porous semiconductor layer, the oxidation swelling of the porous semiconductor layer can be prevented, whereby the influence of distortion on the monocrystalline layer as epitaxially grown can be prevented. According to this method, the monocrystalline Si layer 22 equal to silicon wafer in crystallinity is formed flat and yet uniformly thinly over the whole wafer region with a large area on the oxidized Si layer 24 which is an insulating material. The semiconductor substrate thus obtained can be suitably used also with respect to preparation of an insulation separated electronic device.

Here, the thickness of the non-porous semiconductor crystalline layer to be formed on the porous semiconductor substrate may be desirably made preferably 50 μm or less, more preferably 20 μm or less, for forming a thin film semiconductor device on the above semiconductor monocrystalline layer.

Bonding between the above non porous

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semiconductor monocrystal and the substrate having the insulating material surface should be preferably performed in an atmosphere of nitrogen, an inert gas or a gas mixture of these, or in an atmosphere containing an inert gas or nitrogen, and further desirably under heated state.

As the etchant for selectively etching the above semiconductor substrate as made porous with the above non-porous semiconductor monocrystalline layer as bonded onto the substrate having the insulating material surface being left to remain, for example, there may be employed etchants such as aqueous sodium hydroxide solution, aqueous potassium hydroxide solution, hydrofluoric acid-nitric acid-acetic acid mixed solution, etc.

The substrate having an insulating material which can be used in the present invention may be one with at least its surface being constituted of an insulating material, or one with all of the substrate being constituted of an insulating material. Examples of the substrate with the surface being constituted of an insulating material may include monocrystalline or polycrystalline silicon substrates having the surface oxidized, electroconductive or semiconductive substrates having a layer of an insulating material such as oxide, nitride, boride, etc. formed on the

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surface, etc. Specific examples of the substrates wholly constituted of an insulating material may include substrates comprising insulating materials such as fused silica glass, sintered alumina, etc.

Meanwhile, in the present Embodiment 1, an example of forming a non-porous semiconductor monocrystalline layer on a porous semiconductor substrate has been shown, but the present invention is not limited only to the mode of the Embodiment 1 as described above, but a porous semiconductor substrate having a non-porous semiconductor monocrystalline layer may be also formed by applying a pore forming treatment on a substrate having a monocrystalline layer comprising a material which can be made porous with difficulty (e.g. N-type silicon) and a layer comprising a material which can be readily made porous (e.g. P-type silicon).

Also, in the step of removing the porous semiconductor substrate by etching, the substrate may be also coated with an etching preventive material except for the porous semiconductor substrate during etching, so that the non-porous semiconductor monocrystalline layer and the substrate having the insulating material surface may not be deleteriously influenced by the etchant.

The non-porous monocrystalline layer on the

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insulating material thus formed can be one having 5.0 x 10^{-4} sec. or longer in terms of the life time of carriers, having remarkably less crystal defect such as through dislocation, etc. and also being extremely small in distribution of the layer thickness of the semiconductor monocrystalline layer. Specifically, the dislocation defect density becomes 2 x $10^{4}/cm^{2}$ or less, and concerning the layer thickness of the semiconductor monocrystalline layer, within the range of the area of the semiconductor monocrystalline layer from 20 cm^{2} to 500 cm^{2} (2 inches wafer to 10 inches wafer), the difference between the maximum value and the minimum value of the thickness of the semiconductor monocrystalline layer can be suppressed below 10% or less based on the maximum value.

In the following, other embodiments are shown.

Embodiment 2

Referring now to Figs. 2A to 2D, Embodiment 2 is described in detail.

First, as shown in Fig. 2A, a low impurity concentration layer 122 is formed by epitaxial growth according to various thin film growth methods. Alternatively, protons may be ion implanted into the surface of the P-type Si monocrystalline substrate 121 to form an N-type monocrystalline layer 122.

Next, as shown in Fig. 2B, the back surface of

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the P-type monocrystalline substrate 121 is denatured into a porous Si substrate 123 according to the anodization method by use of an HF solution. The porous Si layer 123 can be varied in its density to a range of 1.1 to 0.6 g/cm^3 by varying the HF solution concentration within the range of 50 to 20% as compared with the density of the monocrystalline Si of 2.33 g/cm^3. The porous layer, as described above, is formed on the P-type substrate.

As shown in Fig. 2C, by providing another Si substrate 124 and after forming an oxidized layer 126 on its surface, the Si substrate 124 having the oxidized layer 125 on its surface is bonded to the surface of the monocrystalline Si layer 122 on the porous Si substrate 123.

Then, the porous Si substrate 123 is all etched to leave a monocrystalline silicon layer 122 as thin film on the SiO_2 layer 125, thereby forming a semiconductor substrate.

According to this process, the monocrystalline Si layer 122 equal in crystallinity to silicon wafer is formed on the oxidized layer 125 which is an insulating material to be flat and to be yet made uniformly into thin layer, over the whole wafer region with a large area.

The semiconductor substrate thus obtained can

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be used suitably also with respect to preparation of an insulation separated electronic device.

The above Embodiment 2 is an example of the process of forming an N-type layer on a P-type substrate before pore formation, and then making selectively only the P-type substrate porous by anodization. Also in the present Embodiment, a semiconductor substrate having a semiconductor monocrystalline layer with the same performances as Embodiment 1 can be obtained.

Embodiment 3

As shown in Fig. 3A, first a P-type Si monocrystalline substrate is prepared and all of it is made porous. According to various growth methods, epitaxial growth is effected on the substrate surface made porous to form a thin film monocrystalline layer 12.

As shown in Fig. 3B, by preparing another Si substrate 13 and after forming an oxidized layer 14 on its surface, the Si substrate having the oxidized layer 14 on the surface is bonded to the surface of the monocrystalline Si layer 12 on the porous Si substrate 11.

Next, as shown in Fig. 3B, an Si_3N_4 layer 15 is deposited to cover over the whole of the bonded two silicon wafers as the anti-etching film.

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Subsequently, as shown in Fig. 3C, the Si_3N_4 layer on the surface of the porous silicon substrate is removed. As another anti-etching film material, Apiezon Wax may be also employed in place of Si_3N_4. Then, the porous Si substrate 11 is all etched and a monocrystalline silicon layer 12 made into a thin film remains on the SiO_2 layer 14 to form a semiconductor substrate.

Fig. 3C shows a semiconductor substrate obtained in the present invention. More specifically, by removing the Si_3N_4 layer 15 as the anti-etching film in Fig. 3B, a monocrystalline Si layer 12 of which crystallinity is equal to that of bulk wafer is formed through the SiO_2 layer 14 which is an insulating substance on the Si substrate 13, flat and yet uniformly into a thin layer, over the whole wafer region with a large area. The semiconductor substrate thus obtained can be used suitably also with respect to preparation of a discrete insulated electronic device. Also in the present Embodiment, a semiconductor substrate having a semiconductor monocrystalline layer with the same performances as Embodiment 1 can be obtained.

Embodiment 4

Referring now to Figs. 4A to 4B, the Embodiment 4 of the present invention is described

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below in detail.

First, as shown in Fig. 4A, a low impurity concentration layer 112 is formed by epitaxial growth according to various thin film growth methods. Alternatively, protons may be ion-implanted into the surface of the P-type Si monocrystalline substrate 111 to form an N-type monocrystalline layer 112.

Next, as shown in Fig. 4B, the back surface of the P-type monocrystalline substrate 111 is denatured into a porous Si substrate 113 according to the anodization method by use of an HF solution. The porous Si layer 113 can be varied in its density to a range of 1.1 to 0.6 g/cm^3 by varying the HF solution concentration to 50 to 20% as compared with the density of the monocrystalline Si of 2.33 g/cm^3. The porous layer 113, as described above, is formed from the P-type substrate.

As shown in Fig. 4C, by preparing another Si substrate 114 and after forming an oxidized layer 115 on its surface, the Si substrate 114 having the oxidized layer 115 on the surface is bonded on the surface of the monocrystalline Si layer 112 on the porous Si substrate 113.

Here, as shown in Fig. 4C, as the anti-etching film 116, an Si_3N_4 layer 116 is deposited to cover over the whole of the bonded two silicon wafers as the

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anti-etching film. Subsequently, as shown in Fig. 4C, the Si_3N_4 layer on the surface of the porous silicon substrate is removed. As another anti-etching film 116, a material excellent in etching resistance such as Apiezon Wax may be also employed in place of Si_3N_4. Then, the porous Si substrate 113 is all etched to form a semiconductor substrate by retaining a monocrystalline silicon layer 112 made into a thin film on the SiO_2 layer 115. Fig. 4D shows a substrate having the semiconductor layer obtained in the present invention. That is, by removing the Si_3N_4 layer 116 as the anti-etching film 116 shown in Fig. 4C, a monocrystalline Si layer 112 is formed on the SiO_2 layer 115 which is the insulating material, flat and yet uniformly into a thin layer, over the whole wafer region with a large area.

The semiconductor thus obtained will not be deleteriously affected by the etchant, and can be used suitably also with respect to preparation of a discrete insulated electronic device.

Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 6

As shown in Fig. 5A, first, a P-type Si monocrystalline substrate is prepared and all of it is

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made porous. A thin film monocrystalline layer 32 is formed by effecting epitaxial growth on the substrate surface made porous according to various growth methods.

As shown in Fig. 5B, by preparing another Si substrate 33 and after forming an oxidized layer 34 on its surface, the Si substrate 33 having the oxidized layer 34 on the surface is bonded to the surface of the oxidized layer 36 formed on the monocrystalline Si layer 32 on the porous substrate 31. The bonding step is practiced by closely contacting the cleaned surfaces with each other, followed by heating in an inert gas atmosphere or nitrogen atmosphere. The oxidized layer 34 is formed in order to reduce the interface level of the non-porous monocrystalline layer 32 which is the final active layer. As shown in Fig. 5B, an Si_3N_4 layer 35 is deposited as the anti-etching film to be coated on the bonded two silicon wafers as a whole. Subsequently, as shown in Fig. 5C, the Si_3N_4 layer 35 on the surface of the porous silicon substrate 31 is removed. As another anti-etching film material, Apiezon Wax, etc. may be also employed in place of Si_3N_4. Then, all of the porous Si substrate 31 is etched to have the monocrystalline silicon layer 32 made into a thin film remain on the SiO_2 layer, thereby forming a semiconductor substrate.

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Fig. 5C shows the substrate having the semiconductor layer obtained in the present invention. More specifically, by removing the Si_3N_4 layer 35 as the anti-etching film shown in Fig 5B, the monocrystalline Si layer 32 equal in crystallinity to silicon wafer is formed through the SiO_2 layers 34 and 36 on the Si substrate 33, flat and yet uniformly into a thin layer, over the whole wafer region with a large area. The semiconductor substrate thus obtained can be used suitably also with respect to preparation of a discrete insulated electronic device. Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 6

Referring now to Figs. 6A to 6D, the Embodiment 6 of the present invention is described below in detail.

First, as shown in Fig. 6A, a low impurity concentration layer 132 is formed by epitaxial growth according to various thin film growth methods. Alternatively, the surface of the P-type Si monocrystalline substrate 131 is subjected to ion implantation of protons to form an N-type monocrystalline layer 132.

Next, as shown in Fig. 6B, the P-type Si

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monocrystalline substrate 131 is denatured from the back surface to a porous Si substrate 133 by the anodization method with an HF solution. The porous Si layer 133 can be varied in its density in the range of 1.1 to 0.6 g/cm^3 by varying the HF solution concentration to 50 to 20% as compared with the density of the monocrystalline Si of 2.33 g/cm^3. The porous layer, as described above, is formed from the P-type substrate.

As shown in Fig. 6C, by preparing another Si substrate 134 and after forming an oxidized layer 135 on its surface, the Si substrate 134 having the oxidized layer 135 is bonded onto the surface of the oxidized layer 137 formed on the monocrystalline Si layer 132 on the porous Si substrate 133.

Subsequently, as the anti-etching film 136, an Si_3N_4 layer 136 is deposited to be coated on the bonded two silicon wafers as a whole. Then, as shown in Fig. 6D, the Si_3N_4 layer 136 on the surface of the porous silicon substrate 133 is removed. Then the porous Si substrate 131 is all chemically etched to have a monocrystalline silicon layer made into a thin film remain on the SiO_2 layers 135 and 137, thereby forming a semiconductor substrate.

The semiconductor substrate thus obtained is excellent in adhesion between the respective layers,

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and can be alao used suitable also with respect to preparation of an isolation separated electronic device. Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 7

As shown in Fig. 7A, first, a P-type Si monocrystalline substrate is prepared and all of it is made porous. According to various growth methods, epitaxial growth is effected on the substrate surface made porous to form a thin film monocrystalline layer 42. As shown in Fig. 7B, by preparing another Si substrate 43 and after forming an oxidized layer 44 on its surface, the Si substrate 43 having the above oxidized layer 44 on the surface is bonded onto the surface of the oxidized layer 45 formed on the monocrystalline Si layer 42 on the porous Si substrate 41. This bonding step is practiced by closely contacting cleaned surfaces with each other, followed by heating in an inert gas atmosphere or nitrogen atmosphere. The oxidized layer 44 is formed in order to reduce the interface level of the monocrystalline layer 42 which is the active layer as the final semiconductor. As shown in Fig. 7C, the porous Si substrate 41 is all etched to have the monocrystalline silicon layer made into a thin film on the SiO_2 layers

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44 and 45, thereby forming a semiconductor substrate. Fig. 7C shows the semiconductor substrate obtained in the present invention.

A monocrystalline Si layer 42 equal in crystallinity to silicon wafer is formed through the SiO_2 layers 44 and 45 on the Si substrate 43, flat and yet uniformly into a thin layer, over the whole wafer region with a large area. The semiconductor substrate thus obtained can be also used suitably also as seen from the standpoint of preparation of an isolation separated electron device. Also, the semiconductor substrate obtained in the present embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 8

Referring now to Figs. 8A to 8D, the Embodiment 8 of the present invention is described below in detail.

First, as shown in Fig. 8A, a low impurity concentration layer 142 is formed by epitaxial growth according to various thin film growth methods. Alternatively, the surface of the P-type Si monocrystalline substrate 141 is subjected to ion implantation of protons to form an N-type monocrystalline layer 142.

Next, as shown in Fig. 8B, the P-type Si monocrystalline substrate 141 is denatured from the

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back surface to a porous Si subetratc 143 by the anodization method with an HF solution. The porous Si layer 143 can be varied in its density in the range of 1.1 to 0.6 g/cm^3 by varying the HP solution concentration to 50 to 20% as compared with the density of the monocrystalline Si of 2.33 g/cm^3. The porous layer, as described above, is formed on the P-type substrate 141.

As shown in Fig. 8C, by preparing another Si substrate 144 and after forming an oxidized layer 145 on its surface, the Si substrate 144 having the oxidized layer 145 is bonded onto the surface of the oxidized layer 146 formed on the monocrystalline Si layer 142 on the porous Si substrate 143.

Then the porous Si substrate is all chemically etched to have a monocrystalline silicon layer made into a thin film remain on the SiO_2 layers 145 and 146, thereby forming a semiconductor substrate.

Fig. 8D shows the semiconductor substrate obtained in the present invention. A monocrystalline Si layer 142 equal in crystallinity to silicon wafer is formed through the SiO_2 layers 145 and 146 on the Si substrate 144, flat and yet uniformly into a thin layer, over the whole wafer region with a large area.

The semiconductor substrate thus obtained can be also used suitably also with respect to preparation

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of an isolation separated electronic device. Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 9

As shown in Fig. 9A, first, a P-type Si monocrystalline substrate is prepared, and all of it is made porous. According to various growth methods, epitaxial growth is effected on the surface of the substrate 51 made porous to form a thin film monocrystalline layer 52.

As shown in Fig. 9B, a light-transmissive substrate 53 represented by glass is prepared and the light-transmissive substrate 53 is bonded onto the surface of the monocrystalline Si layer 52 on the porous Si substrate 51.

Here, as shown in Fig. 9B, as the anti-etching film 54, an Si_3N_4 layer 54 is deposited to be coasted on the bonded two substrates as a whole.

Subsequently, as shown in Fig. 9C, the Si_3N_4 layer 54 on the surface of the porous silicon substrate is removed. Then, the porous Si substrate 51 is all etched away to have a monocrystalline silicon layer 52 made into a thin film remain on the light-transmissive substrate 53, thereby forming a semiconducor substrate. Fig. 9C shows the semiconductor substrate

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obtained in the present invention.

The semiconductor substrate thus obtained can be also used suitable also as seen from the standpoint of preparation of an electronic device isolation separated with a light-transmissive insulating material. Also, the semiconductor obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 10

Referring now to Figs. 10A to 10D, the Embodiment 10 of the present invention is described below in detail.

First, as shown in Fig. 10A, a low impurity concentration layer 152 is formed by epitaxial growth according to various thin film growth methods. Alternatively, the surface of the P-type Si monocrystalline substrate 151 is subjected to ion implantation of protons to form an N-type monocrystalline layer 152.

Next, as shown in Fig. 10B, the P-type Si monocrystalline substrate 151 is denatured from the back surface to a porous Si substrate 153 by the anodization method with an HF solution. The porous Si layer 153 can be varied in its density in the range of 1.1 to 0.6 g/cm^3 by varying the HF solution concentration to 50 to 20% as compared with the

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density of the monocrystalline Si of 2.33 g/cm^3. The porous layer 153, as described above, is formed on the P-type substrate 151.

As shown in Fig. 10C, after preparing a light-transmissive substrate 154, onto the surface of the monocrystalline Si layer 152 on the porous Si substrate 153 is bonded the light-transmissive substrate 154. Then, as shown in Fig. 10C, as an anti-etching film 155, an Si_3N_4 layer, etc. is deposited to be coated on the bonded two substrates as a whole. Subsequently, as shown in Fig. 10D, the Si_3N_4 layer 155 on the surface of the porous silicon substrate 153 is removed. Then, the porous Si substrate 153 is all etched away to have the monocrystalline silicon layer 152 made into a thin film remain on the light-transmissive substrate 154, thereby forming a semiconductor substrate.

Fig. 10D shows the semiconductor substrate obtained in the present invention. It is the monocrystalline Si layer 152 equal in crystallinity to silicon wafer formed on the light-transmissive substrate 154, flat and yet uniformly into a thin layer, over the whole wafer region with a large area.

The semiconductor substrate thus obtained can be also used suitably also with respect to preparation of an isolation separated electronic device with a

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light-transmissive insulating material. Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 11

As shown in Fig. 11A, first, a P-type Si monocrystalline substrate is prepared, and all of it is made porous. According to various growth methods, epitaxial growth is effected on the surface of the substrate 61 made porous to form a thin film monocrystalline layer 62.

As shown in Fig. 11B, a light-transmissive substrate 63 represented by glass is prepared and the light-transmissive substrate 63 is bonded to the surface of the monocrystalline Si layer 62 on the porous Si substrate 61.

Then, the porous Si substrate 61 is all etched to have the monocrystalline silicon layer 62 made into a thin film remain on the light-transmissive substrate 63, thereby forming a semiconductor substrate.

Fig. 11C shows the semiconductor substrate obtained in the present invention. It is the monocrystalline Si layer 62 equal in crystallinity to silicon wafer formed on the light-transmissive substrate 63, flat and yet uniformly into a thin layer, over the whole wafer region with a large area.

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The semiconductor thus obtained can be also suitably used also with respect to preparation of an electronic device isolation separated with a light-transmissive insulating material.

Embodiment 12

Referring now to Figs. 12A to 12D, the Embodiment 12 of the present invention is described below in detail.

First, as shown in Fig. 12A, a low impurity concentration layer 162 is formed by epitaxial growth according to various thin film growth methods. Alternatively, the surface of the P-type Si monocrystalline substrate 161 is subjected to ion implantation of protons to form an N-type monocrystalline layer 162.

Next, as shown in Fig. 12B, the P-type Si monocrystalline substrate 161 is denatured from the back surface to a porous Si substrate 163 by the anodization method with an HF solution. The porous Si layer 163 can be varied in its density in the range of 1.1 to 0.6 g/cm^3 by varying the HF solution concentration to 50 to 20% as compared with the density of the monocrystalline Si of 2.33 g/cm^3. The porous layer 163, as described above, is formed on the P-type substrate 163.

As shown in Fig. 12C, after preparing a light-

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transmissive substrate 164, onto the surface of the monocrystalline Si layer 162 on the porous Si substrate 163 is bonded the light-transmissive substrate 164. As shown in Fig. 12C, the porous Si substrate 163 is all etched away to have the monocrystalline silicon layer 162 made into a thin film remain on the light-transmissive substrate 164, thereby forming a semiconductor substrate.

Fig. 12D shows the semiconductor substrate obtained in the present invention. It is the monocrystalline Si layer 162 equal in crystallinity to silicon wafer formed on the light-transmissive substrate 164, flat and yet uniformly into a thin layer, over the whole wafer region with a large area.

The semiconductor substrate thus obtained can be also used suitably also with respect to preparation of an isolation separated electronic device with a light-transmissive insulating material. Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 13

This Embodiment is described by referring to Figs. 13A to 13F. As shown in Fig. 13A, first a porous region 1301 is formed on a part of an Si monocrystalline substrate 1300. Subsequently, a thin

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film Si monocrystalline layer 1302 is formed according to various crystal growth methods on the porous region 1301 (Fig. 13B). On the thin film Si monocrystalline layer 1302 is formed an oxidized film 1303 (Fig. 13C).

The oxidized film 1305 formed on the surface of another Si substrate 1304 is bonded to the above oxidized film 1303 (Fig. 13D).

Subsequently, the Si monocrystalline substrate 1300 remaining without being made porous is removed by mechanical polishing or etching to have the porous region 1301 exposed (Fig. 13E).

The porous region 1301 is etched away to form a semiconductor substrate having a thin film Si monocrystalline layer on an insulating material (Fig. 13F).

When such step is employed, the time required for making the substrate porous can be shortened and also the time for etching away the porous Si substrate can be shortened, whereby substrate formation can be effected highly efficiently.

It is also possible to bond the thin film Si monocrystalline layer 1302 directly to the oxidized film 1305 without forming the oxidized film 1303 shown in Fig. 13, and it is also possible to bond an insulating substrate such as glass, etc. in place of the oxidized film 1305 formed on the Si substrate

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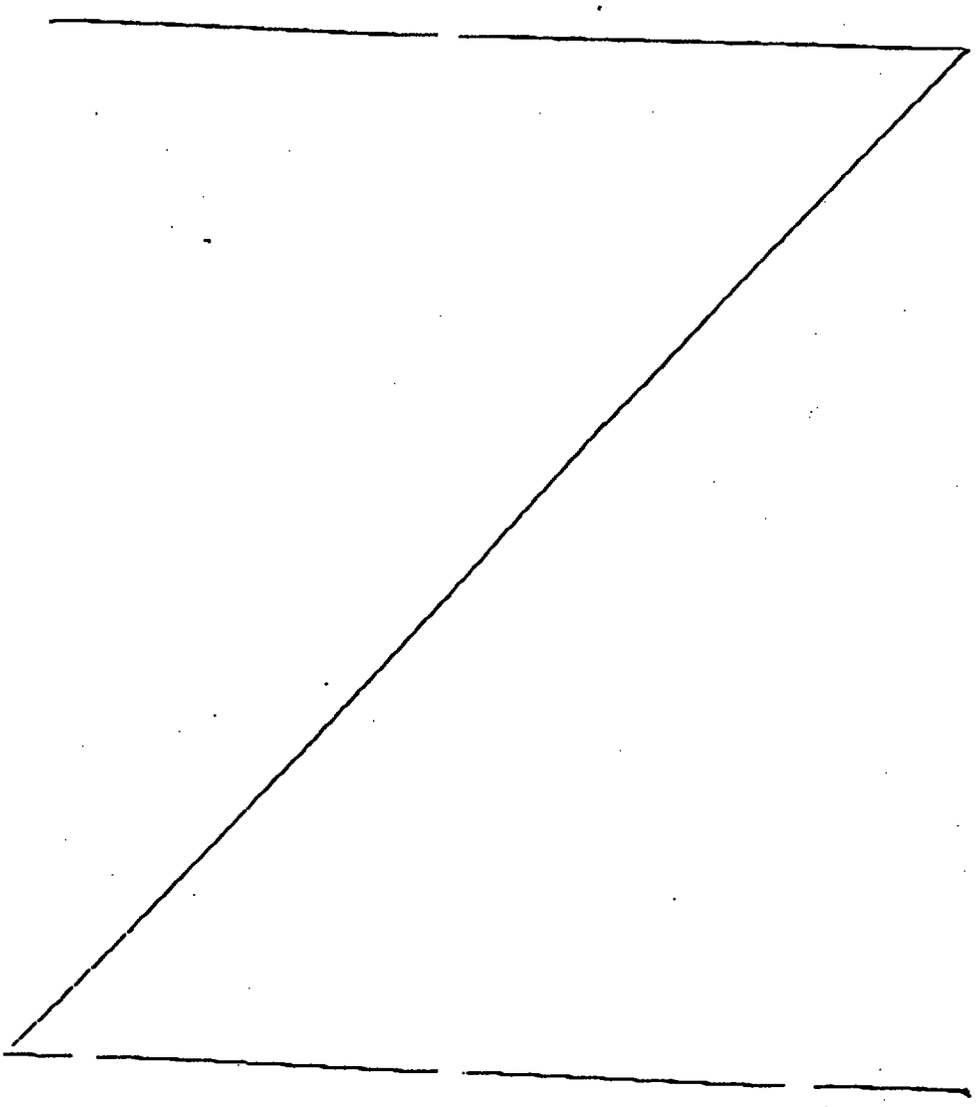


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Also, the respective steps in the Embodiments 1 to 12 can be also incorporated in the present Embodiment.

The semiconductor substrate thus obtained has the same excellent performances as those of the semiconductor substrate obtained in Embodiments 1 to 12.



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Example 1

A P-type (100) monocrystalline Si substrate (Si wafer) having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 21 was grown an Si epitaxial layer to a thickness of 0.5 microns by the MBE (Molecular Beam Epitaxy) method. The deposition conditions are as follows:

Temperature: 700 ^{o}C

Pressure: 1×10^{-9} Torr

Growth rate: 0.1 nm/sec.

Next, on the surface of the epitaxial layer 21 was superposed another Si substrate 23 with an oxidized layer of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 21 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8).

As described above, chemical etching rate of ordinary Si monocrystal relative to hydrofluoric acid-

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nitric acid-acetic acid solution is about a little lower than 1 micron per minute (hydrofluoric acid-nitric acid-acetic acid solution, 1:3:8), but the chemical etching rate of a porous layer is accelerated by about 100-fold thereof. That is, the Si substrate 21 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a monocrystalline Si layer 22 having a thickness of 0.5 μm could be formed on the SiO_2 layer 24.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. Specifically, the whole surface of the 3 inches wafer was scanned for the measurement. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed $1 \times 10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life

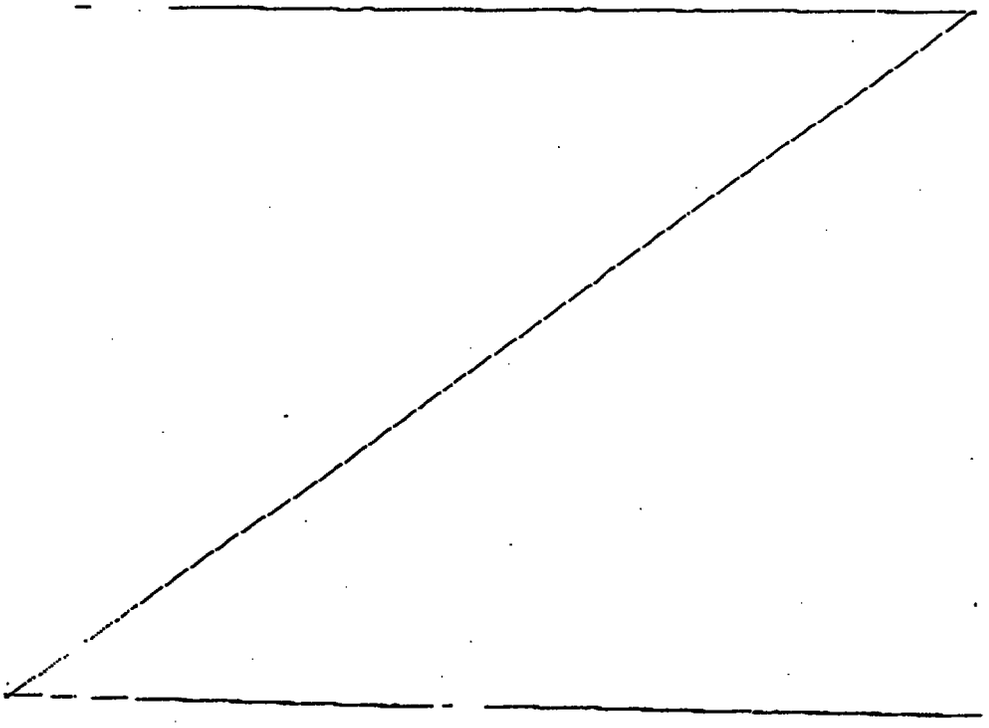
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time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0×10^{-3} sec. was exhibited.

Example 2

A P-type (100) monocrystalline Si substrate having a diameter of 4 inches and a thickness of 500 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 500 microns as a whole was made porous in 60 minutes.



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On the P-type (100) porous Si substrate 21 was grown at low temperature an Si epitaxial layer 22 to a thickness of 0.5 microns by the plasma CVD method. The deposition conditions are as follows:

Gas: SiH_4

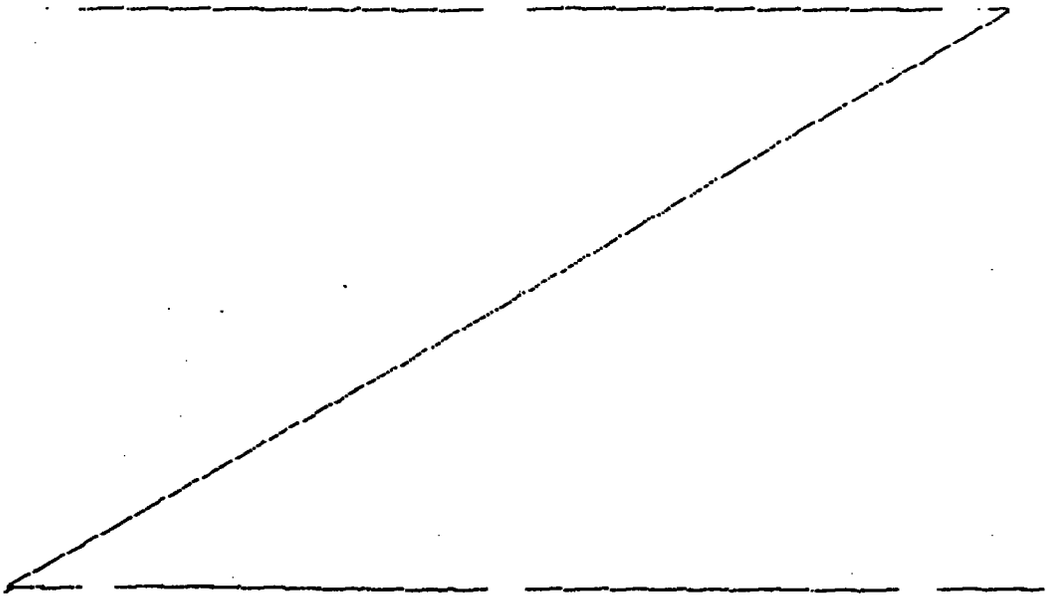
Radio frequency power: 100 W

Temperature: 800 ^{o}C

Pressure: 1×10^{-2} Torr

Growth rate: 2.5 nm/sec.

Next, on the surface of the epitaxial layer 22 was superposed another Si substrate 23 with an oxidized layer 24 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 700 ^{o}C for 0.5 hour, the two Si substrates were bonded



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firmly together. Then, the porous Si substrate 21 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8).

As described above, chemical etching rate of ordinary Si monocrystal relative to hydrofluoric acid-nitric acid-acetic acid solution is about a little lower than 1 micron per minute (hydrofluoric acid-nitric acid-acetic acid solution, 1:3:8), but the chemical etching rate of a porous layer is accelerated by about 100-fold thereof. That is, the Si substrate 21 made porous having a thickness of 500 microns was removed in 5 minutes.

Thus, a monocrystalline Si layer having a thickness of 0.5 μm could be formed on the SiO_2 layer 24.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. Specifically, the whole surface of the 4 inches wafer was scanned for the measurement. As the result, within the plane of the 4 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 7% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron

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microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0 x 10^{-3} sec. was exhibited.

Example 3

A P-type (100) monocrystalline Si substrate (Si wafer) having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 21 was grown an Si epitaxial layer 22 to a thickness of 0.5 microns by the bias-sputtering method. The deposition conditions are as follows:

RF frequency: 100 MHz

Radio frequency power: 600 W

Temperature: 300 °C

Ar gas pressure: 8 x 10^{-3} Torr

Growth time: 60 minutes

Target direct current bias: - 200 V

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Substrate direct current bias: + 5 V.

Next, on the surface of the epitaxial layer 22 was superposed another Si substrate 23 with an oxidized layer 24 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 21 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8).

As described above, chemical etching rate of ordinary Si monocrystal to hydrofluoric acid-nitric acid-acetic acid solution is about a little lower than 1 micron per minute (hydrofluoric acid-nitric acid-acetic acid solution, 1:3:8), the chemical etching rate of a porous layer is accelerated by about 100-fold thereof. That is, the Si substrate 21 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a monocrystalline Si layer having a thickness of 0.5 μm could be formed on the SiO_2 layer 24.

Example 4

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The

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porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 21 was grown an Si epitaxial layer 22 to a thickness of 0.5 microns by the liquid phase growth method. The growth conditions are as follows:

Solvent: Sn

Growth temperature: 900 ^{o}C

Growth atmosphere: H_2

Growth time: 10 minutes.

Next, on the surface of the epitaxial layer 22 was superposed another Si substrate 23 with an oxidized layer 24 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 21 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 21 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a monocrystalline Si layer 22 having a thickness of 0.5 μm could be formed on the SiO_2 layer 24.

Example 5

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A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous atructure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 21 was grown an Si epitaxial layer 21 to a thickness of 0.5 microns by the low pressure CVD method. The deposition conditions are as follows:

Source gas: SiH_4

Carrier gas: H_2

Temperature: 850 ^oC

Pressure: 1×10^{-2} Torr

Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 22 was superposed another Si substrate with an oxidized layer 24 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^oC for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 21 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 21 made porous having a thickness of 200 microns was removed in 2 minutes.

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Thus, a monocrystalline Si layer having a thickness of 0.5 μm could be formed on the SiO_2 layer 24. When SiH_2Cl_2 was employed as the source gas, although it was necessary to elevate the growth temperture by some ten degrees, the accelerted etching characteristics inherent in the porous substrate were maintained.

Example 6

On a P-type (100) Si substrate 121 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 122 with a thickness of 1 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 2 min.

The substrate 121 was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 121 having a thickness of 200 microns as a whole was made porous in 24 minutes. In this anodization, only the P-type (100) Si substrate 121 was made porous, and there was no change in the Si epitaxial layer 122.

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Next, on the surface of the epitaxial layer 122 was superposed another Si substrate 124 with an oxidized layer 125 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.6 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 123 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 123 made porous having a thickness of 200 microns was removed in 2 minutes.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^{3}/cm^{2}$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the

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microwave reflection method, a high value of 2.0×10^{-3} sec. was exhibited.

Example 7

On a P-type (100) Si substrate having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 122 to a thickness of 0.5 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 121 having a thickness of 200 microns as a whole was made porous in 24 minutes. In this anodization, only the P-type (100) Si substrate was made porous, and there was no change in the Si epitaxial layer 122.

Next, on the surface of the epitaxial layer 122 was superposed another Si substrate 124 with an oxidized layer 125 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded

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firmly together. Then, the porous Si substrate 123 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 123 made porous having a thickness of 200 microns was removed in 2 minutes.

As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the Si layer 122 to maintain good crystallinity.

Example 8

On a surface of a P-type (100) Si substrate 121 having a diameter of 3 inches and a thickness of 200 microns was formed an N-type Si layer 122 to a thickness of 1 micron by ion implantation of protons into the surface. The amount of H^+ implanted was found to be 5×10^{15} (ions/cm^2). The substrate 121 was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 121 having a thickness of 200 microns as a whole was made porous in 24 minutes. As described above, in this anodization, only the P-type (100) Si substrate 121 was made porous, and there was no change in the N-type Si layer 122. Next, on the surface of the N-type Si layer 122

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was superposed another Si substrate 124 with an oxidized layer 125 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 123 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 123 made porous having a thickness of 200 microns was removed in 2 minutes.

As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the Si layer 122 to maintain good crystallinity.

Example 9

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 11 was grown an Si epitaxial layer 12 to a thickness of 0.5 microns by the MBE (Molecular Beam Epitaxy) method.

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The deposition conditions are as follows:

Temperature: 700 ^{o}C

Pressure: 1 x 10^{-9} Torr

Growth rate: 0.1 nm/sec.

Next, on the surface of the epitaxial layer 12 was superposed another Si substrate 13 with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 µm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 11 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 15, a substrate having a monocrystalline Si layer having a thickness of 0.5 µm on the SiO_2 layer 14 could be formed.

As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

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Example 10

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P type (100) porous Si substrate 11 was grown an Si epitaxial layer 12 to a thickness of 0.5 microns by the plasma CVD method. The deposition conditions are as follows:

Gas: SiH_4

Radio frequency power: 100 W

Temperature: 800 ^oC

Pressure: 1 x 10^{-2} Torr

Growth rate: 2.5 nm/sec.

Next, on the surface of the epitaxial layer 12 was superposed another Si substrate with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^oC for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon

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nitride film on the porous substrate 11 was removed by reactive ion etching. Then, the porous Si substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acid acetic acid solution (1:3:8). As the result, the Si substrate 11 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 15, a substrate having a monocrystalline Si layer 12 having a thickness of 0.5 μm on the SiO_2 layer could be formed.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of observation by defect delineation etching by use of Sirtle etching, the dislocation defect density was found to be suppressed $1 \times 10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0×10^{-3} sec. was exhibited.

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Example 11

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 11 was grown an Si epitaxial layer 12 to a thickness of 0.6 microns by the bias sputtering method. The deposition conditions are as follows:

RF frequency: 100 MHz

Radio frequency power: 600 W

Temperature: 300 °C

Ar gas pressure: 8×10^{-3} Torr

Growth time: 60 min.

Target direct current bias: -200 V

Substrate direct current bias: + 5 V

Next, on the surface of the epitaxial layer 12 was superposed another Si substrate with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a

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thickness of 0.1 μm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 11 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 15, a substrate having a monocrystalline Si layer 12 having a thickness of 0.5 μm on the SiO_2 layer 14 could be formed.

Also, the same effect was obtained when Apiezon Wax was coated in place of the Si_3N_4 layer, and only the Si substrate made porous could be completely removed.

Example 12

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 11 was grown an Si epitaxial layer 12 to a thickness of 0.5 microns by the liquid phase growth method. The

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growth conditions are as follows:

Solvent: Sn

Growth temperature: 900 °C

Growth atmosphere: H_2

Growth time: 10 min.

Next, on the surface of the epitaxial layer 12 was superposed another Si substrate 13 with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 11 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 15, a substrate having a monocrystalline Si layer 12 having a thickness of 0.5 μm on the SiO_2 layer 14 could be formed.

Also, the same effect was obtained when Apiezon Wax was coated in place of the Si_3N_4 layer, and only the Si substrate made porous could be

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completely removed.

Example 13

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 11 was grown an Si epitaxial layer 12 to a thickness of 0.5 microns by the low pressure CVD method. The deposition conditions are as follows:

Source gas: SiH_4

Carrier gas: H_2

Temperature: 850 ^oC

Pressure: 1×10^{-2} Torr

Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 12 was superposed another Si substrate 13 with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^oC for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon

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nitride film 15 on the porous substrate 11 was removed by reactive ion etching. Then, the porous Si substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 11 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 15, a substrate having a monocrystalline Si layer having a thickness of 0.5 µm on the SiO_2 layer 14 could be formed.

When SiH_2Cl_2 was employed as the source gas, although it was required to elevate the growth temperature by some ten degrees, the accelerated chemical etching characteristics inherent in the porous substrate could be maintained.

Example 14

On a P-type (100) Si substrate 111 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 112 with a thickness of 1 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 2 min.

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The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 111 having a thickness of 200 microns as a whole was made porous in 24 minutes. In this anodization, only the P-type (100) Si substrate 111 was made porous, and there was no change in the Si epitaxial layer 112. Next, on the surface of the epitaxial layer 112 was superposed another Si substrate 114 with an oxidized layer of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1μm. Thereafter, only the nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 111 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 113 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 116, a substrate having a monocrystalline Si layer 112 having a thickness of 1 μm could be formed on SiO_2.

Also the thickness of the monocrystalline Si

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layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed $1 \times 10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the microwave reflection method, a high value of 2.0×10^{-3} sec. was exhibited.

Example 15

On a P-type (100) Si substrate 111 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 112 to a thickness of 0.5 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 ^oC

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Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 111 having a thickness of 200 microns as a whole was made porous in 24 minutes. In this anodization, only the P-type (100) Si substrate 111 was made porous, and there was no change in the Si epitaxial layer 112.

Next, on the surface of the epitaxial layer 112 was superposed an Si substrate 114 with an oxidized layer of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon nitride film 116 on the porous substrate 113 was removed by reactive ion etching. Then, the porous Si substrate 113 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 113 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 116, a substrate having a monocrystalline Si layer 112 having

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a thickness of 0.5 μm could be formed on the SiO_2 layer 115. As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 16

On a surface of a P-type (100) Si substrate 111 having a diameter of 3 inches and a thickness of 200 microns was formed an N-type Si layer 112 to a thickness of 1 micron by ion implantation of protons into the surface. The amount of H^+ implanted was found to be 5×10^{15} (ions/cm^2). The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 111 having a thickness of 200 microns as a whole was made porous in 24 minutes. In this anodization, only the P-type (100) Si substrate 111 was made porous, and there was no change in the N-type Si layer 112. Next, on the surface of the N-type Si layer 112 was superposed another Si substrate 114 with an oxidized layer 115 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the Si substrates were bonded firmly together. Subsequently, Si_3N_4 was coated on

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the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 113 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 113 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 116, a substrate having a monocrystalline Si layer 112 having a thickness of 1.0 μm could be formed on the SiO_2. As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 17

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 31 was

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grown an Si epitaxial layer 32 to a thickness of 0.5 microns by the MBE (Molecular Beam Epitaxy) method. The deposition conditions are as follows:

Temperature: 700 ^{o}C

Pressure: 1 x 10 ^{9} Torr

Growth rate: 0.1 nm/sec.

Next, on the surface of the epitaxial layer 32 was formed an oxide layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate having an oxide layer 34 of 5000 angstroms formed on the surface was superposed the above oxide layer 36, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the both were bonded firmly together. Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 µm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 31 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 35, a substrate having a thin film monocrystalline Si layer 32 could be formed on the SiO_2. As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal

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defect had been introduced in the Si layer to maintain good crystallinity.

Example 18

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 31 was grown an Si epitaxial layer 32 to a thickness of 5 microns according to the plasma CVD method. The deposition conditions are as follows:

Gas: SiH_4

Radio frequency power: 100 W

Temperature: 800 ^oC

Pressure: 1×10^{-2} Torr

Growth rate: 2.5 nm/sec.

Next, on the surface of the epitaxial layer 32 was formed an oxide layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate 33 having an oxide layer 34 of 5000 angstroms formed on the surface was superposed the above oxide layer 36, and by heating in a nitrogen atmosphere at 800 ^oC for 0.5 hour, the both were bonded firmly together. Si_3N_4 was

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coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 31 was chemically etched away by use of a KOH solution (6 M). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer, a substrate having a monocrystalline Si layer 32 with good crystallinity could be formed on the SiO_2 layer.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the

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monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0×10^{-3} sec. was exhibited.

Example 19

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 31 was grown an Si epitaxial layer 32 to a thickness of 1 micron according to the bias sputtering method. The deposition conditions are as follows:

RF frequency: 100 MHz

Radio frequency power: 600 W

Temperature: 800 °C

Ar gas pressure: 8×10^{-3} Torr

Growth time: 120 min.

Target direct current bias: - 200 V

Substrate direct curren bias: + 5V

Next, on the surface of the epitaxial layer 32 was formed an oxide layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate 33 having an oxide layer 34 of 5000 angstroms formed on the surface was superposed the above oxide layer 36, and by

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heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the both were bonded firmly together. Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the nitride film on the porous substrate 31 was removed by reactive ion etching. Then, the porous Si substrate 31 was chemically etched away by use of a hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer, a substrate having a monocrystalline Si layer 32 with good crystallinity could be formed on the SiO_2 layer.

The same effect was obtained also when Apiezon Wax was coated in place of the Si_3N_4 layer 35, whereby only the Si substrate 35 made porous could be completely removed.

Example 20

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate

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31 was grown an Si epitaxial layer 32 to a thickness of 5 micron by the liquid phase growth method. The growth conditions are as follows:

Solvent: Sn

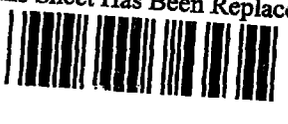
Growth temperature: 900 °C

Growth atmospherc: H_2

Growth time: 10 min.

Next, on the surface of the epitaxial layer 32 was formed an oxide layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate 33 having an oxide layer 34 of 5000 angstroms formed on the surface was superposed the above oxide layer 36, and by heating in a nitrogen atmosphere at 700 °C for 0.5 hour, the both were bonded firmly together. Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon nitride film on the porous substrate wac removed by reactive ion etching. Then, the porous Si substrate 31 was chemically etched away by use of a hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 35, a substrate having a monocrystalline Si layer 32 could be formed on the SiO_2. The same effect was obtained also when Apiezon Wax was coated in place of the Si_3N_4 layer.

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whereby only the Si substrate made porous could be completely removed.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed $1 \times 10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0×10^{-3} sec. was exhibited.

Example 21

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a

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thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 31 was grown an Si epitaxial layer 32 to a thickness of 1.0 micron at low temperature by the low pressure CVD method. The deposition conditions are as follows:

Source gas: SiH_4

Carrier gas: H_2

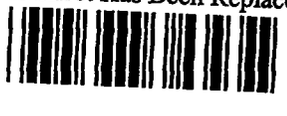
Temperature: 850 ^{o}C

Pressure: 1 x 10^{-2} Torr

Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 32 was formed an oxidized layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate 33 having an oxide layer 34 of 5000 angstroms formed on the surface was superposed the above oxide layer 36, and by heating in a nitrogen atmosphere at 700 ^{o}C for 0.5 hour, the both were bonded firmly together. Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon nitride film 35 on the porous substrate 31 was removed by reactive ion etching. Then, the porous Si substrate 31 was chemically etched away by use of a hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 35, a

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substrate having a monocrystalline Si layer 32 could be formed on the SiO_2 layer.

When SiH_2Cl_2 was employed as the source gas, although the growth temperature was required to be elevated by some ten degrees, the accelerated chemical etching characteristics inherent in the porous substrate could be maintained.

Example 22

On a P-type (100) Si substrate 131 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 132 with a thickness of 1 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 2 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 131 having a thickness of 200 microns as a whole was made porous in 24 minutes.. As described above, only the P-type (100) Si substrate 131 was made porous in this anodization, and there was no change in the Si

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epitaxial layer 132. Next, on the surface of the epitaxial layer 132 was formed an oxidized layer 137, another Si substrate 134 having an oxidized layer 135 of 5000 angstroms formed on the surface was superposed on the above oxidized layer 137, and the two Si substrates were bonded together firmly by heating at 800 °C for 0.5 hour in a nitrogen atmosphere. By the low pressure CVD method, Si_3N_4 was coated with a thickness of 0.1 µm on the bonded substrate. Then only the silicon nitride film on the porous substrate was removed by reactive ion etching. Subsequently, the porous Si substrate 133 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 133 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 136, a substrate having the monocrystalline Si layer 132 having a thickness of 1 µm could be formed on SiO_2.

As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 23

On a P-type (100) Si substrate 131 having a diameter of 4 inches and a thickness of 500 microns

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was grown an Si epitaxial layer 132 with a thickness of 0.5 micron by the CVD method. The deposition conditions are so follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 131 having a thickness of 500 microns as a whole was made porous. Only the P-type (100) Si substrate 131 was made porous in this anodization, and there was no change in the Si epitaxial layer 132.

Next, on the surface of the epitaxial layer 132 was formed an oxidized layer 137 with a thickness of 1000 angstroms. Then, another Si substrate 134 having an oxidized layer 135 of 5000 angstroms formed on the surface was adhered on the above oxidized layer 137, and the both were bonded together firmly by heating at 700 °C for 0.5 hour in a nitrogen atmosphere. By the low pressure CVD method, Si_3N_4 was coated with a thickness of 0.1 μm on the bonded substrate, and only the silicon nitride film 136 on

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the porous substrate 133 was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate made porous having a thickness of 500 microns was removed in 5 minutes. After removal of the Si_3N_4 layer 136, a substrate having the monocrystalline Si layer 132 could be formed on SiO_2.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 4 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 8% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed $1 \times 10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.1×10^{-3} sec. was exhibited.

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Example 24

On the surface of a P-type (100) Si substrate 131 having a diameter of 3 inches and a thickness of 200 microns was formed N-type Si layer 132 with a thickness of 1 micron by ion implantation of protons. The amount of H^+ implanted was 5×10^{15} (ions/cm^2). The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 131 having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si substrate 131 was made porous in this anodization, and there was no change in the N-type Si layer 132. Next, on the surface of the epitaxial layer 132 was formed an oxidized layer 137 with a thickness of 1000 angstroms. Then, another Si substrate 134 having an oxidized layer 135 of 5000 angstroms formed on the surface was adhered on the above oxidized layer 137, and the two Si substrates were bonded together firmly by heating at 700 ^{o}C for 0.5 hour. By the low pressure CVD method, Si_3N_4 was coated with a thickness of 0.1 μm on the bonded substrate. Then, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Subsequently, the porous Si substrate 133 was chemically etched away by use of hydrofluoric

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acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 136, a substrate having the monocrystalline Si layer 132 could be formed on SiO_2. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystalline defect had been introduced in the Si layer to maintain good crystallinity.

Example 25

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 41 was grown an Si epitaxial layer 42 to a thickness of 0.5 microns by the MBE (Molecular Beam Epitaxy) method. The deposition conditions are as follows:

Temperature: 700 ^oC

Pressure: 1 x 10^{-9} Torr

Growth rate: 0.1 nm/sec.

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Next, on the surface of the epitaxial layer 42 was formed an oxidized layer 45 with a thickness of 1000 angstroms. Then, another Si substrate 43 with an oxidized layer 44 of 5000 angstroms formed on the surface was superposed on the above oxidized layer 45, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 41 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 41 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a substrate having a thin film monocrystalline Si layer 42 could be formed on the SiO_2. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 26

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in

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24 minutes. On the P-type (100) porous Si substrate 41 was grown an Si epitaxial layer 42 to a thickness of 5 microns by the plasma CVD method. The deposition conditions are as follows:

Gas: SiH_4

Radio frequency power: 100 W

Temperature: 800 ^{o}C

Pressure: 1 x 10^{-2} Torr

Growth rate: 2.6 nm/sec.

Next, on the surface of the epitaxial layer 42 was formed an oxidized layer 45 with a thickness of 1000 angstroms. Then, another Si substrate 43 with an oxidized layer 44 of 5000 angstroms formed on the surface was superposed on the above oxidized layer 45, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 41 was chemically etched away by use of a KOH solution of 6 M.

As described above, ordinary chemical etching rate of Si monocrystal relative to 6M KOH solution is about a little lower than 1 micron per minute, but the chemical etching rate of a porous layer is accelerated by about 100-fold thereof. Then, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes.

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Thus, a monocrystalline Si layer having good crystallinity could be formed on the SiO_2.

Example 27

A P-type (100) monocrystalline Si substrate having a diameter of 5 inches and a thickness of 600 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 600 microns as a whole was made porous in 70 minutes. On the P-type (100) porous Si substrate 41 was grown an Si epitaxial layer 42 to a thickness of 1 micron by the bias-sputtering method. The deposition conditions are as follows:

RF frequency: 100 MHz

Radio frequency power: 600 w

Temperature: 300 ^{o}C

Ar gas pressure: 8×10^{-3} Torr

Growth time: 120 minutes

Target direct current bias: - 200 V

Substrate direct current bias: + 5 V.

Next, on the surface of the epitaxial layer 42 was formed an oxidized layer 45 with a thickness of 1000 angstroms. Then, another Si substrate 43 with an oxidized layer 44 of 5000 angstroms formed on the surface was superposed on the above oxidized layer 45,

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and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 41 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 41 made porous having a thickness of 600 microns was removed in 7 minutes.

Thus, a substrate having a monocrystalline Si layer 42 with good crystallinity could be formed on the SiO_2.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 5 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 8% or less based on the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed $1 \times 10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method,

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a high value of 2.1×10^{-3} sec. was exhibited.

Example 28

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 41 was grown an Si epitaxial layer 42 to a thickness of 5 microns by the liquid phase growth method. The growth conditions are as follows:

Solvent: Sn

Growth temperature: 900 °C

Growth atmosphere: H_2

Growth time: 10 minutes.

Next, on the surface of the epitaxial layer 42 was formed an oxidized layer 45 with a thickness of 1000 angstroms. Then, another Si substrate 43 having an oxidized layer 44 of 5000 angstroms formed on the surface was closely contacted, and by heating in a nitrogen atmosphere at 700 °C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 41 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid

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solution (1:3:8). As the result, the Si substrate 41 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a substrate having a monocrystalline Si layer could be formed on the SiO_2.

Example 29

A P type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 41 was grown an Si epitaxial layer 42 to a thickness of 1.0 microns by to the low pressure CVD method. The deposition conditions are as follows:

Source gas: SiH_4

Carrier gas: H_2

Temperature: 650 ^oC

Pressure: 1×10^{-2} Torr

Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 42 was formed an oxidized layer 45 with a thickness of 1000 angstroms. Then, another Si substrate 43 having an oxidized layer 44 of 5000 angstroms on the surface

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was closely contacted, and by heating in a nitrogen atmosphere at 700 °C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, the porous Si substrate 41 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 41 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a substrate having a monocrystalline Si layer 42 on SiO_2 could be formed. When SiH_2Cl_2 was employed, although it was necessary to elevate the growth temperature by some ten degrees, the accelerated chemical etching characteristics inherent in the porous substrate were maintained.

Example 30

On a P-type (100) Si substrate 141 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 142 with a thickness of 1 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM
H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 2 min.

The substrate was anodized in a 50% HF

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solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous. Only the P-type (100) Si substrate 141 was made porous in this anodization, and there was no change in the Si epitaxial layer 142. Next, on the surface of the epitaxial layer 142 was superposed another Si substrate 144 having an oxidized layer 145 of 5000 angstroms formed on the surface , and the two Si substrates were bonded together firmly by heating at 800 °C for 0.5 hour in a nitrogen atmosphere. Subsequently, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a substrate having a monocrystalline layer 142 with a thickness of 1 μm on SiO_2 could be formed. As the result of cross-sectional observation by a transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 31

On a P-type (100) Si substrate 141 having a

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diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 142 with a thickness of 0.5 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 141 having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si substrate 141 was made porous in this anodization, and there was no change in the Si epitaxial layer 142.

Next, on the surface of the epitaxial layer 142 was formed an oxidized layer 146 with a thickness of 1000 angstroms. Then, another Si substrate having an oxidized layer 145 of 5000 angstroms formed on the surface was closely contacted, and the two Si substrates were bonded together firmly by heating at 700 °C for 0.5 hour. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the

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result, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a substrate having a monocrystalline Si layer on SiO_2 could be formed. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 32

On the surface of a P-type (100) Si substrate 141 having a diameter of 3 inches and a thickness of 200 microns was formed an N-type Si layer 142 with a thickness of 1 micron by ion implantation of protons. The amount of H^+ implanted was 5×10^{15} (ions/cm^2). The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si substrate 141 was made porous in this anodization, and there was no change in the N-type Si layer 142. Next, on the surface of the epitaxial layer 142 was formed an oxidized layer 146 with a thickness of 1000 angstroms. Then, another Si substrate having an oxidized layer 145 of 5000 angstroms formed on the surface was

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closely contacted with the above oxidized layer 146, and the two Si substrates were bonded together firmly by heating at 700 °C for 0.5 hour. Subsequently, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes.

A substrate having a monocrystalline Si layer on SiO_2 could be formed.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less based on the maximum value of the thickness. As the result of plan-view observation of the monocrystalline Si layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed $1 \times 10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline layer by use of the MOS C-t method, a

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high value of 2.2×10^{-3} sec. was exhibited.

Example 33

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 51 was grown an Si epitaxial layer 52 to a thickness of 0.5 microns at a low temperature by the MBE method. The deposition conditions are as follows:

Temperature: 700 ^{o}C

Pressure: 1×10^{-9} Torr

Growth rate: 0.1 nm/sec.

Next, on the surface of the epitaxial layer 52 was superposed a fused silica substrate applied with optical polishing, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two substrates were bonded firmly together. By the low pressure CVD method, Si_3N_4 was coated on the bonded substrate with a thickness of 0.1 μm. Subsequently, only the nitride film 54 on the porous substrate 51 was removed by reactive ion etching. Then, the porous Si

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substrate 51 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 51 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 54, a substrate having the monocrystalline Si layer 52 with a thickness of 0.5 μm on the fused silica 53 could be obtained.

As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 34

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 51 was grown an Si epitaxial layer 52 to a thickness of 5 microns by the plasma CVD method. The deposition conditions are as follows:

Gas: SiH_4

Radio frequency power: 100 W

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Temperature: 800 °C

Pressure: 1 x 10^{-2} Torr

Growth rate: 2.5 nm/sec.

Next, on the surface of the epitaxial layer 52 was superposed a glass substrate having a softening point around 500 °C applied with optical polishing, and by heating in a nitrogen atmosphere at 450 °C for 0.5 hour, the two substrates were bonded firmly together. By the low pressure CVD method, Si_3N_4 was coated on the bonded substrate with a thickness of 0.1 µm. Subsequently, only the nitride film 54 on the porous substrate 51 was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of 6M KOH solution. As the result, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer, the monocrystalline layer 52 with a thickness of 5 µm on the low softening glass substrate 53 could be obtained.

Example 35

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 µm/min. and the P-type (100) Si substrate having a

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thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 51 was grown an Si epitaxial layer to a thickness of 1.0 micron by the bias-sputtering method. The deposition conditions are as follows:

RF frequency: 100 MHz

Radio frequency power: 600 W

Temperature: 300 ^{o}C

Ar gas pressure: 8 x 10^{-3} Torr

Growth time: 120 minutes

Target direct current bias: - 200 V

Substrate direct current bias: + 5 V.

Next, on the surface of the epitaxial layer 52 was superposed a glass substrate 53 having a softening point around 500 ^{o}C applied with optical polishing, and by heating in a nitrogen atmosphere at 450 ^{o}C for 0.5 hour, the two substrate were bonded firmly together. By the low pressure CVD method, Si_3N_4 was coated on the bonded substrate with a thickness of 0.1 µm. Subsequently, only the nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 51 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4

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layer 54, a substrate having the monocrystalline layer 52 with a thickness of 1.0 μm on the low melting point glass could be obtained. The same effect could be also obtained when Apiezon Wax was coated in place of the Si_3N_4 layer, and only the Si substrate 51 made porous could be removed.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less based on the maximum value of the thickness. As the result of plan-view observation of the monocrystalline Si layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed $1 \times 10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0×10^{-3} sec. was exhibited.

Example 36

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200

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microne was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 51 was grown an Si epitaxial layer to a thickness of 10 microns by the liquid phase growth method. The growth conditions are as follows:

Solvent: Sn

Growth temperature: 900 °C

Growth atmosphere: H_2

Growth time: 20 minutes.

Next, on the surface of the epitaxial layer 52 was superposed a glass substrate 53 having a softening point around 800 °C applied with optical polishing, and by heating in a nitrogen atmosphere at 750 °C for 0.5 hour, the two substrates were bonded firmly together. By the low pressure CVD method, Si_3N_4 was coated on the bonded substrate with a thickness of 0.1 μm. Subsequently, only the nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 51 made porous having a thickness of 200 microns was

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removed in 2 minutes. After removal of the Si_3N_4 layer 54, a substrate having the monocrystalline Si layer 52 with a thickness of 10 μm on the glass 53 could be obtained. The same effect could be also obtained when Apiezon Wax was coated in place of the Si_3N_4 layer, and only the Si substrate made porous could be completely removed.

Example 37

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 51 was grown an Si epitaxial layer 52 to a thickness of 1.0 micron by the low pressure CVD method. The deposition conditions are as follows:

Source gas: SiH_4 800 SCCM

Carrier gas: H_2 150 l/min.

Temperature: 850 ^oC

Pressure: 1 x 10^{-2} Torr

Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 52 was superposed a fused silica substrate 53 applied

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with optical polishing, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together.

By the low pressure CVD method, Si_3N_4 was coated on the bonded substrate with a thickness of 0.1 μm. Subsequently, only the nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 51 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution. As the result, the Si substrate 51 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer, a substrate having the monocrystalline Si layer 52 with a thickness of 1.0 μm on the fused silica substrate 53 could be formed.

When SiH_2Cl_2 as the source gas was employed, although it was necessary to elevate the growth temperature by some ten degrees, the accelerated chemical etching characteristics inherent in the porous substrate were maintained.

Example 38

On a P-type (100) Si substrate 151 having a diameter of 4 inches and a thickness of 300 microns was grown an Si epitaxial layer 152 with a thickness of 1 micron by the CVD method. The deposition conditions are as follows:

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Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 2 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 151 having a thickness of 300 microns as a whole was made porous in 36 minutes. As described above, only the P-type (100) Si substrate 151 was made porous in this anodization, and there was no change in the Si epitaxial layer 152. Next, on the surface of the epitaxial layer 152 was superposed a fused silica substrate 154 applied with optical polishing, and the two substrate were bonded together firmly by heating at 800 °C for 0.5 hour in a nitrogen atmosphere. By the low pressure CVD method, Si_3N_4 was deposited with a thickness of 0.1 μm to be coated on the bonded substrate. Subsequently the nitride film 155 on the porous substrate 153 was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 153 made porous having a thickness of 300

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microne was removed in 4 minutes. After removal of the Si_3N_4 layer 155, a substrate having the monocrystalline Si layer 152 having a thickness of 1 μm on the fused silica substrate 154 could be formed.

As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 39

On a P-type (100) Si substrate 151 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 152 with a thickness of 0.5 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 151 having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si substrate was made porous in this anodization, and

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there was no change in the Si epitaxial layer 152.

Next, on the surface of the epitaxial layer 152 was superposed a fused silica substrate 154 applied with optical polishing, and the two substrates were bonded together firmly by heating at 800 ^{o}C for 0.5 hour. By the low pressure CVD method, Si_3N_4 was deposited with a thickness of 0.1 µm to be coated on the bonded substrate. Subsequently the nitride film 155 on the porous substrate 153 was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 153 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 155, a substrate having the monocrystalline Si layer 152 having a thickness of 0.5 µm on the fused silica 154 could be formed. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 40

On the surface of a P-type (100) Si substrate 151 having a diameter of 4 inches and a thickness of 300 microns was formed an N-type Si layer 152 with a thickness of 1 micron by ion implantation of protons.

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The amount of H+ implanted was 5 x 1015 (ions/cm^2). The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 151 having a thickness of 300 microns as a whole was made porous in 37 minutes. Only the P type (100) Si substrate was made porous in this anodization, and there was no change in the N-type Si layer 152. Next, on the surface of the N type Si layer 152 was superposed a fused silica substrate 154 with optical polishing, and the two substrates were bonded together firmly by heating at 800 ^{o}C for 0.5 hour in a nitrogen atmosphere. By the low pressure CVD method, Si_3N_4 was deposited to a thickness of 0.1 μm to be coated on the bonded substrate. Subsequently, only the nitride film 155 on the porous substate 153 was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution. As the result, the Si substrate 151 made porous having a thickness of 300 microns was removed in 4 minutes. After removal of the Si_3N_4 layer 155, a substrate having the monocrystalline Si layer 152 with a thickness of 1.0 μm on the fused silica 154 could be formed.

Also the thickness of the monocrystalline Si

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layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 4 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 6% or less based on the maximum value of the thickness. As the result of plan-view observation of the monocrystalline Si layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed $1 \times 10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.2×10^{-3} sec. was exhibited.

Shortly speaking, according to the present invention, in obtaining an Si crystalline layer excellent in crystallinity equal to monocrystalline Si wafer also on a light-transparent insulating material substrate represented by glass, a process for forming a semiconductor substrate excellent in aspects of productivity, uniformity, controllability, economy can be provided. Further, according to the present invention, there can be provided a process for forming a semiconductor substrate broad in scope of

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application which can make avail of the advantages of the SOI device of the prior.

Example 41

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 61 was grown an Si epitaxial layer 62 to a thickness of 0.5 microns by the MBE method. The deposition conditions are as follows:

Temperature: 700 ^{o}C

Pressure: 1×10^{-9} Torr

Growth rate: 0.1 nm/sec.

Next, on the surface of the epitaxial layer 62 was superposed a fused silica substrate 63 applied with optical polishing, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous Si substrate 61 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution. As the result, the Si substrate 61 made porous having

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a thickness of 200 microns was removed in 2 minutes. A substrate having the monocrystalline Si layer 62 with a thickness of 0.5 μm on the fused silica 63 could be obtained. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 42

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 61 was grown an Si epitaxial layer 62 to a thickness of 5 microns by the plasma CVD method. The deposition conditions are as follows:

Gas: SiH_4

Radio frequency power: 100 W

Temperature: 800 ^oC

Pressure: 1×10^{-2} Torr

Growth rate: 2.5 nm/sec.

Next, on the surface of the epitaxial layer 62

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was superposed a glass substrate having a softening point around 500 °C applied with optical polishing, and by heating in a nitrogen atmosphere at 450 °C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous Si substrate 61 was chemically etched away by use of 6M KOH solution. As the result, the Si substrate 61 made porous having a thickness of 200 microns was removed in 2 minutes. A substrate having the monocrystalline Si layer 62 with a thickness of 5 μm on the low softening point glass 63 could be obtained.

Example 43

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 61 was grown an Si epitaxial layer 62 to a thickness of 1.0 micron by the bias-sputtering method. The deposition conditions are as follows:

RF frequency: 100 MHz

Radio frequency power: 600 W

Temperature: 300 °C

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Ar gas pressure: 8×10^{-3} Torr

Growth time: 120 minutes

Target direct current bias: - 200 V

Substrate direct current bias: + 5 V.

Next, on the surface of the epitaxial layer 62 was superposed a glass substrate 63 having a softening point around 500 °C applied with optical polishing, and by heating in a nitrogen atmosphere at 450 °C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous Si substrate 61 was chemically etched away by use of 7 M NaOH solution.

As described above, the chemical etching rate of ordinary Si monocrystal relative to 7 M NaOH solution is about a little less than 1 micron per minute, but the chemical etching rate of the porous layer is accelerated by about 100-fold thereof. That is, the Si substrate 61 made porous having a thickness of 200 microns was removed in 2 minutes. A substrate having the monocrystalline Si layer 62 with a thickness of 1.0 μm on the low melting point glass 63 could be formed.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the

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monocrystalline Si layer was found to be suppressed 5% or less based on the maximum value of the thickness. As the result of plan-view observation of the monocrystalline Si layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline layer by use of the MOS C-t method, a high value of 2.1 x 10^{-3} sec. was exhibited.

Example 44-

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 61 was grown an Si epitaxial layer 62 to a thickness of 10 microns by the liquid phase growth method. The growth conditions are as follows:

Solvent: Sn

Growth temperature: 900 ^oC

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Growth atmosphere: H_2

Growth time: 20 minutes.

Next, on the surface of the epitaxial layer 62 was superposed a glass substrate 63 having a softening point around 800 °C applied with optical polishing, and by heating in a nitrogen atmosphere at 750 °C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous Si substrate 61 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution. As the result, the Si substrate 61 made porous having a thickness of 200 microns was removed in 2 minutes. A substrate having the monocrystalline Si layer 62 with a thickness of 10 µm on the glass 63 could be obtained.

Example 45

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 µm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 61 was grown an Si epitaxial layer to a thickness of 1.0 micron by the low pressure CVD method. The deposition conditions are as follows:

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Source gas: SiH_4 800 SCCM

Carrier gas: H_2 150 l/min.

Temperature: 850 °C

Pressure: 1×10^{-2} Torr

Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 62 was superposed a fused silica substrate 63 applied with optical polishing, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous Si subatrate 61 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution. As the result, the Si substrate 61 made porous having a thickness of 200 microns was removed in 2 minutes. A substrate having the monocrystalline Si layer 62 with a thickness of 1.0 µm on the fused silica 63 could be formed. When SiH_2Cl_2 as the source gas was employed, although it was necessary to elevate the growth temperature by some ten degrees, the accelerated chemical etching characteristics inherent in the porous substrate were maintained.

Example 46

On a P-type (100) Si substrate 161 having a diameter of 4 inches and a thickness of 300 microns was grown an Si epitaxial layer 162 with a thickness of 1 micron by the CVD method. The deposition

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conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 2 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 161 having a thickness of 300 microns as a whole was made porous in 37 minutes. Only the P-type (100) Si substrate 161 was made porous in this anodization, and there was no change in the Si epitaxial layer 162. Next, on the surface of the epitaxial layer was superposed an optical polished fused silica glass substrate 164 and the two substrates were bonded together firmly by heating at 800 °C for 0.5 hour in a nitrogen atmosphere. Then, the porous Si substrate 163 was chemically etched away by use of hydrofluoric acid nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 163 made porous having a thickness of 300 microns was removed in 4 minutes. A substrate having the monocrystalline Si layer 162 having a thickness of 1 μm on the fused silica glass substrate 164 could be formed.

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Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 4 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 7% or less based on the maximum value of the thickness. As the result of plan-view observation of the monocrystalline Si layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed $1 \times 10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0×10^{-3} sec. was exhibited.

Example 47

On a P-type (100) Si substrate 161 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 162 with a thickness of 0.5 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

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Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 161 having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si substrate 161 was made porous in this anodization, and there was no change in the Si epitaxial layer 162.

Next, on the surface of the epitaxial layer 162 was superposed an optical polished fused silica glass substrate 164 and the two substrates were bonded together firmly by heating at 800 °C for 0.5 hour. Then, the porous Si substrate 163 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution. As the result, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes. A monocrystalline Si layer having a thickness of 0.6 μm on the glass substrate could be formed. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystalline defect had been introduced in the Si layer to maintain good crystallinity.

Example 48

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On the surface of a P-type (100) Si substrate 161 having a diameter of 3 inches and a thickness of 200 microns was formed an N-type Si layer 162 with a thickness of 1 micron by ion implantation of protons. The amount of H^+ implanted was 5×10^{15} (ions/cm^2). The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 µm/min. and the P-type (100) Si substrate 161 having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si substrate 161 was made porous in this anodization, and there was no change in the N-type Si layer 162. Next, on the surface of the epitaxial layer 162 was superposed an optical polished fused silica glass substrate 164 and the two substrates were bonded together firmly by heating at 800 °C for 0.5 hour. Then, the porous Si substrate 163 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 163 made porous having a thickness of 200 microns was removed in 4 minutes. A monocrystalline Si layer 162 with a thickness of 1.0 µm on the glass substrate 164 could be formed. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been

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introduced in the Si layer to maintain good crystallinity.

Example 49

A P-type (100) monocrystalline Si substrate having a diameter of 6 inches and a thickness of 600 microns was anodized in a 50 % HF solution. The current density at this time was 10 mA/cm^2. In 10 minutes, a porous layer having a thickness of 20 microns was formed on the surface. On the P-type (100) porous Si substrate was grown an Si epitaxial layer to a thickness of 0.5 micron by the low pressure CVD method. The deposition conditions are as follows:

Gas: SiH_2Cl_2 (0.6 l/min), H_2 (100 l/min.)

Temperature: 850 ^oC

Pressure: 80 Torr

Growth rate: 0.1 μm/min.

Next, the surface of the epitaxial layer was thermally oxidized to 50 nm. On the thus obtained thermally oxidized film was superposed another silicon substrate having an oxidized layer of 0.8 micron on the surface, and by heating in a nitrogen atmosphere at 900 ^oC for 1.5 hours, the two substrates were firmly bonded together.

Thereafter, grinding of 585 microns was applied from the back side of the silicon substrate to have the porous layer exposed.

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By the plasma CVD method, Si_3N_4 was deposited to a thickness of 0.1 μm to be coated on the bonded substrate. Subsequently, only the silicon nitride film on the porous substrate was removed by reactive ion etching.

Then, the bonded substrate was subjected to chemically selective etching by use of a hydrofluoric acid-nitric acid-acetic acid solution. After 15 minutes, the porous Si layer was chemically selectively etched to be completely removed, and only the monocrystalline Si layer as the etch-stop material remained without being chemically etched.

The chemical etching rate of non-porous Si monocrystalline relative to the etchant is very low as about 40 angstroms even after 15 minutes, whereby the selective ratio of the etching rate between the non-porous layer and the porous layer is very large and the etched amount in the non-porous Si layer was practically negligible. After removal of the Si_3N_4 layer, a monocrystalline Si layer having a thickness of 0.5 μm on the silicon substrate having an insulating layer on the surface could be formed.

The same effect was also obtained, when Apiezon Wax or Electron Wax was coated in place of the Si_3N_4, and only the Si layer made porous could be completely removed.

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Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 6 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 10% or less based on the maximum value of the thickness. As the result of plan view observation of the monocrystalline layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed $1 \times 10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0×10^{-3} sec. was exhibited.

A process for preparing a semiconductor member comprises the steps of:

forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and then

removing the porous monocrystalline semiconductor region by etching.

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WHAT IS CLAIMED IS:

1. A process for preparing a semiconductor member comprising the steps of:

forming a member having a non-poroue monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of said non-porous monocrystalline semiconductor region, and then

removing said porous monocrystalline semiconductor region by etching.

2. A process for preparing a semiconductor member according to Claim 1, wherein said monocrystalline semiconductor comprises silicon.

3. A process for preparing a semiconductor member according to Claim 1, wherein said porous monocrystalline semiconductor region is P-type.

4. A process for preparing a semiconductor member according to Claim 1, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

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6. A process for preparing a semiconductor member according to Claim 1, wherein said bonding step is carried out in an atmosphere containing nitrogen.

6. A process for preparing a semiconductor member according to Claim 1, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

7. A process for preparing a semiconductor member according to Claim 1, wherein said non-porous monocrystalline semiconductor region is formed by epitaxial growth.

8. A process for preparing a semiconductor member according to Claim 1, wherein said non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

9. A process for preparing a semiconductor member according to Claim 1, wherein said porous monocrystalline semiconductor region is obtained by making the non-porous semiconductor monocrystalline

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region porous by anodization.

10. A process for preparing a semiconductor member according to Claim 9, wherein said anodization is carried out in an HF solution.

11. A process for preparing a semiconductor member according to Claim 2, wherein said non-porous monocrystalline semiconductor region is intrinsic or N-type.

12. A process for preparing a semiconductor member according to Claim 11, wherein said N-type silicon is formed by proton irradiation or epitaxial growth.

13. A process for preparing a semiconductor member according to Claim 1, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

14. A process for preparing a semiconductor member according to Claim 1, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

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15. A process for preparing a semiconductor member according to Claim 1, wherein etching of said porous monocrystalline semiconductor region is carried out under the state where the members bonded to each other are covered with an anti-etching material.

16. A process for preparing a semiconductor member according to Claim 15, wherein said anti-etching material is silicon nitride.

17. A process for preparing a semiconductor member according to Claim 15, wherein said anti-etching material is Apiezon Wax.

18. A process for preparing a semiconductor member compriaing the steps of:

forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on the non-porous monocrystalline semiconductor side of said member, then

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of said insulating substance, and

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removing said porous monocrystalline semiconductor region by etching.

19. A process for preparing a semiconductor member according to Claim 18, wherein said monocrystalline semiconductor comprises silicon.

20. A process for preparing a semiconductor member according to Claim 18, wherein said porous monocrystalline semiconductor region is P-type.

21. A process for preparing a semiconductor member according to Claim 18, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

22. A process for preparing a semiconductor member according to Claim 18, wherein said bonding step is carried out in an atmosphere containing nitrogen.

23. A process for preparing a semiconductor member according to Claim 18, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

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24. A process for preparing a semiconductor member according to Claim 18, wherein said non-porous monocrystalline semiconductor region is formed by epitaxial growth.

25. A process for preparing a semiconductor member according to Claim 18, wherein said non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

26. A process for preparing a semiconductor member according to Claim 18, wherein said porous monocrystalline semiconductor region is obtained by making the non-porous semiconductor monocrystalline region porous by anodization.

27. A process for preparing a semiconductor member according to Claim 18, wherein said anodization is carried out in an HF solution.

28. A process for preparing a semiconductor member according to Claim 19, wherein said non-porous monocrystalline semiconductor region is intrinsic or

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N-type.

29. A process for preparing a semiconductor member according to Claim 28, wherein said N-type silicon is formed by proton irradiation or epitaxial growth.

30. A process for preparing a semiconductor member according to Claim 18, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

31. A process for preparing a semiconductor member according to Claim 18, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

32. A process for preparing a semiconductor member according to Claim 18, wherein etching of said porous monocrystalline semiconductor region is carried out under the state where the members bonded to each other are covered with an anti-etching material.

33. A process for preparing a semiconductor member according to Claim 32, wherein said anti-

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etching material is silicon nitride.

34. A process for preparing a semiconductor member according to Claim 32, wherein said anti-etching material is Apiezon Wax.

35. A process for preparing a semiconductor member comprising the steps of:

making a non-porous monocrystalline semiconductor member porous to form a porous monocrystalline semiconductor region,

forming a non-porous monocrystalline semiconductor region on said porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of said non-porous monocrystalline semiconductor region, and

removing said porous monocrystalline semiconductor region by etching.

36. A process for preparing a semiconductor member according to Claim 35, wherein said monocrystalline semiconductor comprises silicon.

37. A process for preparing a semiconductor

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member according to Claim 35, wherein said porous monocrystalline semiconductor region is P-type.

38. A process for preparing a semiconductor member according to Claim 35, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

39. A process for preparing a semiconductor member according to Claim 35, wherein said bonding step is carried out in an atmosphere containing nitrogen.

40. A process for preparing a semiconductor member according to Claim 35, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

41. A process for preparing a semiconductor member according to Claim 35, wherein said non-porous monocrystalline semiconductor region is formed by epitaxial growth.

42. A process for preparing a semiconductor member according to Claim 35, wherein said non-porous monocrystalline semiconductor region is formed

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according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

43. A process for preparing a semiconductor member according to Claim 35, wherein said porous monocrystalline semiconductor region is obtained by anodization.

44. A process for preparing a semiconductor member according to Claim 43, wherein said anodization is carried out in an HF solution.

45. A process for preparing a semiconductor member according to Claim 36, wherein said non-porous monocrystalline semiconductor region is intrinsic or N-type.

46. A process for preparing a semiconductor member according to Claim 45, wherein said N-type silicon is formed by epitaxial growth.

47. A process for preparing a semiconductor member according to Claim 35, wherein the member of which the surface is constituted of an insulating

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substance comprises a light-transmissive material.

48. A process for preparing a semiconductor member according to Claim 35, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

49. A process for preparing a semiconductor member comprising the steps of:

making a non-porous monocrystalline semiconductor member porous to form a porous monocrystalline semiconductor region,

forming a non-porous monocrystalline semiconductor region on said porous monocrystalline semiconductor region,

forming region constituted of an insulating substance on said non-porous monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of said region constituted of the insulating substance, and

removing said porous monocrystalline semiconductor region by etching.

50. A process for preparing a semiconductor

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member according to Claim 49, wherein said monocrystalline semiconductor comprises silicon.

51. A process for preparing a semiconductor member according to Claim 49, wherein said porous monocrystalline semiconductor region is P-type.

52. A process for preparing a semiconductor member according to Claim 49, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

53. A process for preparing a semiconductor member according to Claim 49, wherein said bonding step is carried out in an atmosphere containing nitrogen.

54. A process for preparing a semiconductor member according to Claim 49, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

55. A process for preparing a semiconductor member according to Claim 49, wherein said non-porous monocrystalline semiconductor region is formed by epitaxial growth.

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56. A process for preparing a semiconductor member according to Claim 49, wherein said non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

57. A process for preparing a semiconductor member according to Claim 49, wherein said porous monocrystalline semiconductor region is obtained by anodization.

58. A process for preparing a semiconductor member according to Claim 57, wherein said anodization is carried out in an HF solution.

59. A process for preparing a semiconductor member according to Claim 50, wherein said non-porous monocrystalline semiconductor region is intrinsic or N-type.

60. A process for preparing a semiconductor member according to Claim 59, wherein said N-type silicon is formed by epitaxial growth.

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61. A process for preparing a semiconductor member according to Claim 49, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

62. A process for preparing a semiconductor member according to Claim 49, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

63. A process for preparing a semiconductor member comprising the steps of:

making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region,

forming a third non-porous monocrystalline semiconductor region on said porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of said third non-porous monocrystalline semiconductor region, and

removing said second non-porous

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monocrystalline semiconductor region by mechanical polishing, and removing said porous monocrystalline semiconductor region by etching.

64. A process for preparing a semiconductor member according to Claim 63, wherein said monocrystalline semiconductor comprises silicon.

65. A process for preparing a semiconductor member according to Claim 63, wherein said porous monocrystalline semiconductor region is P-type.

66. A process for preparing a semiconductor member according to Claim 63, wherein said third non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

67. A process for preparing a semiconductor member according to Claim 63, wherein said bonding step is carried out in an atmosphere containing nitrogen.

68. A process for preparing a semiconductor member according to Claim 63, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

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69. A process for preparing a semiconductor member according to Claim 63, wherein said third non-porous monocrystalline semiconductor region is formed by epitaxial growth.

70. A process for preparing a semiconductor member according to Claim 63, wherein said third non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

71. A process for preparing a semiconductor member according to Claim 63, wherein said porous monocrystalline semiconductor region is obtained by anodization.

72. A process for preparing a semiconductor member according to Claim 71, wherein said anodization is carried out in an HF solution.

73. A process for preparing a semiconductor member according to Claim 64, wherein said third non-porous monocrystalline semiconductor region is

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intrinsic or N-type.

74. A process for preparing a semiconductor member according to Claim 73, wherein said N-type silicon is formed by epitaxial growth.

75. A process for preparing a semiconductor member according to Claim 63, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

76. A process for preparing a semiconductor member according to Claim 63, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

77. A process for preparing a semiconductor member comprising the steps of:

making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region,

forming a third non-porous monocrystalline semiconductor region on said porous monocrystalline

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semiconductor region,

forming a region constituted of an insulating substance on said third non-porous monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of said region constituted of the insulating substance, and

removing said second non-porous monocrystalline semiconductor by mechanical polishing, and removing said porous monocrystalline semiconductor region by etching.

78. A process for preparing a semiconductor member according to Claim 77, wherein said monocrystalline semiconductor comprises silicon.

79. A process for preparing a semiconductor member according to Claim 77, wherein said porous monocrystalline semiconductor region is P-type.

80. A process for preparing a semiconductor member according to Claim 77, wherein said third non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

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81. A process for preparing a semiconductor member according to Claim 77, wherein said bonding step is carried out in an atmosphere containing nitrogen.

82. A process for preparing a semiconductor member according to Claim 77, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

83. A process for preparing a semiconductor member according to Claim 77, wherein said third non-porous monocrystalline semiconductor region is formed by epitaxial growth.

84. A process for preparing a semiconductor member according to Claim 77, wherein said third non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

85. A process for preparing a semiconductor member according to Claim 77, wherein said porous monocrystalline semiconductor region is obtained by

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anodization.

86. A process for preparing a semiconductor member according to Claim 85, wherein said anodization is carried out in an HF solution.

87. A process for preparing a semiconductor member accoding to Claim 70, wherein said third non-porous monocrystalline semiconductor region is intrinsic or N-type.

88. A process for preparing a semiconductor member according to Claim 87, wherein said N-type silicon is formed by epitaxial growth.

89. A process for preparing a semiconductor member according to Claim 77, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

90. A process for preparing a semiconductor member according to Claim 77, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

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91. A process for preparing a semiconductor member comprising the steps of:

forming a second monocrystalline semiconductor region of a second electroconduction type on a first monocrystalline semiconductor region of a first electroconduction type,

making said first monocrystalline semiconductor region porous to form a porous single crysalline semiconductor region,

bonding the surface of a member of which the surface is formed of an insulating substance onto the surface of said second single crystlline semiconductor region, and

removing said porous monocrystalline semiconductor region by etching.

92. A process for preparing a semiconductor member according to Claim 91, wherein said monocrystalline semiconductor comprises silicon.

93. A process for preparing a semiconductor member according to Claim 91, wherein said first monocrystalline semiconductor region is P-type.

94. A process for preparing a semiconductor member according to Claim 91, wherein said bonding

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step is carried out in an atmosphere containing nitrogen.

95. A process for preparing a semiconductor member according to Claim 91, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

96. A process for preparing a semiconductor member according to Claim 91, wherein said second non-porous monocrystalline semiconductor region is formed by epitaxial growth.

97. A process for preparing a semiconductor member according to Claim 91, wherein said second non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

98. A process for preparing a semiconductor member according to Claim 91, wherein said porous monocrystalline semiconductor region is obtained by anodization.

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99. A process for preparing a semiconductor member according to Claim 98, wherein said anodization is carried out in an HF solution.

100. A process for preparing a semiconductor member according to Claim 92, wherein said second non-porous monocrystalline semiconductor region is intrinsic or N-type.

101. A process for preparing a semiconductor member according to Claim 100, wherein said N-type silicon is formed by epitaxial growth.

102. A process for preparing a semiconductor member according to Claim 91, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

103. A process for preparing a semiconductor member according to Claim 91, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

104. A process for preparing a semiconductor member comprising the steps of:

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forming a second monocrystalline semiconductor region of a second electroconduction type on a first monocrystalline semiconductor region of a first electroconduction type,

making said first monocrystalline semiconductor region porous to form a porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on said second monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is formed of an insulating substance onto the surface of said region constituted of an insulating substance, and

removing said porous monocrystalline semiconductor region by etching.

105. A process for preparing a semiconductor member according to Claim 104, wherein said monocrystalline semiconductor comprises silicon.

106. A process for preparing a semiconductor member according to Claim 104, wherein said first non-monocrystalline semiconductor region is P-type.

107. A process for preparing a semiconductor member according to Claim 104, wherein said non-porous

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monocrystalline semiconductor region has a thickness of 50 microns or less.

108. A process for preparing a semiconductor member according to Claim 104, wherein said bonding step is carried out in an atmosphere containing nitrogen.

109. A process for preparing a semiconductor member according to Claim 104, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

110. A process for preparing a semiconductor member according to Claim 104, wherein said second non-porous monocrystalline semiconductor region is formed by epitaxial growth.

111. A process for preparing a semiconductor member according to Claim 104, wherein said second non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

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112. A process for preparing a semiconductor member according to Claim 104, wherein said porous monocrystalline semiconductor region is obtained by anodization.

113. A process for preparing a semiconductor member according to Claim 112, wherein said anodization is carried out in an HF solution.

114. A process for preparing a semiconductor member accoding to Claim 105, wherein said second non-porous monocrystalline semiconductor region is intrinsic or N-type.

115. A process for preparing a semiconductor member according to Claim 114, wherein said N-type silicon is formed by proton irradiation or epitaxial growth.

116. A process for preparing a semiconductor member according to Claim 104, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

117. A process for preparing a semiconductor member according to Claim 104, wherein the member of

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which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

118. A semiconductor member comprising:

a first member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region, and

a second member having the surface constituted of an insulating subetance bonded onto the surface of said non-porous monocrystalline semiconductor region.

119. A semiconductor member according to Claim 118, wherein said monocrystalline semiconductor comprises silicon.

120. A semiconductor member according to Claim 118, wherein said porous monocrystalline semiconductor region is P-type.

121. A semiconductor member according to Claim 118, wherein said non-porous monocrystalline semiconductor region hae a thickness of 50 microns or less.

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122. A semiconductor member comprising:

a first member having a non-porous monocrystalline semiconductor region and a region constituted of an insulating substance arranged in this order on a porous monocrystalline semiconductor region, and

a second member bonded through a region constituted of an insulating substance onto the surface of said region constituted of the insulating substance.

123. A semiconductor member according to Claim 122, wherein said monocrystalline semiconductor comprises silicon.

124. A semiconductor member according to Claim 122, wherein said porous monocrystalline semiconductor region is P-type.

125. A semiconductor member according to Claim 122, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

126. A semiconductor member having a non-porous silicon monocrystalline semiconductor region arranged

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on a region constituted of an insulating substance, characterized in that the dislocation defect density in said non-porous silicon monocrystalline semiconductor region is $2.0 \times 10^4/cm^2$ or less, and the life time of carriers is 5.0×10^{-4} sec or longer.

127. A semiconductor member having a non-porous silicon monocrystalline semiconductor region arranged on a region constituted of an insulating substance, characterized in that the dislocation defect deneity in said non-porous silicon monocrystalline semiconductor region is $2.0 \times 10^4/cm^2$ or less, and the life time of carriers is 5.0×10^{-4} sec or longer, and also the difference between the maximum value and the minimum value of the thickness of said silicon monocrystalline semiconductor region is 10% or less based on said maximum value.

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ABSTRACT OF THE DISCLOSURE

A process for preparing a semiconductor member comprises the steps of:

forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and then

removing the porous monocrystalline semiconductor region by etching.

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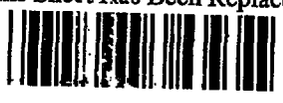


FIG. 1A

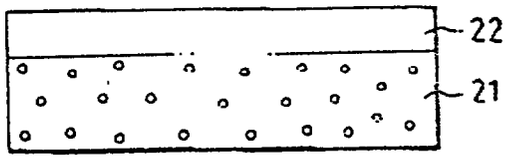


FIG. 1B

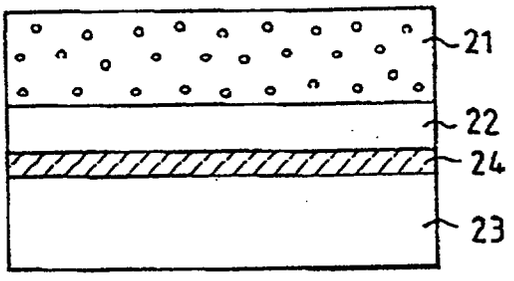


FIG. 1C

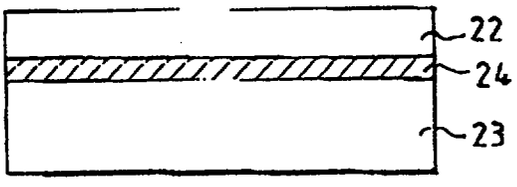


FIG. 2A

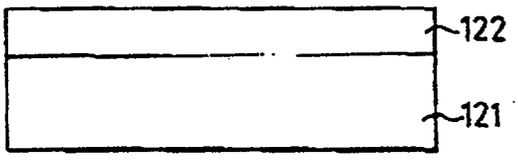


FIG. 2B

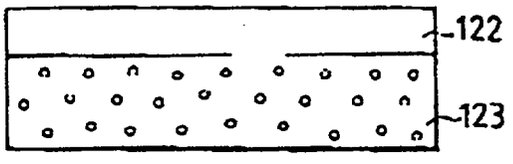


FIG. 2C

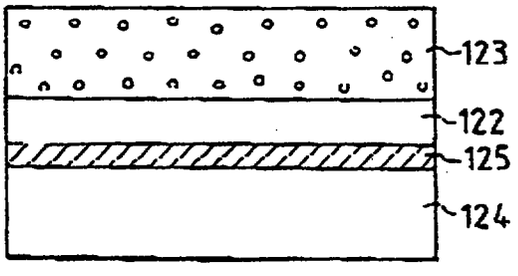
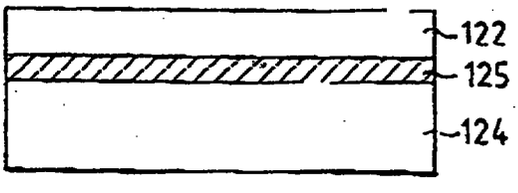


FIG. 2D



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FIG. 3A

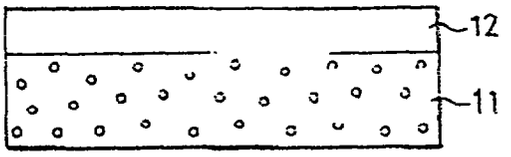


FIG. 3B

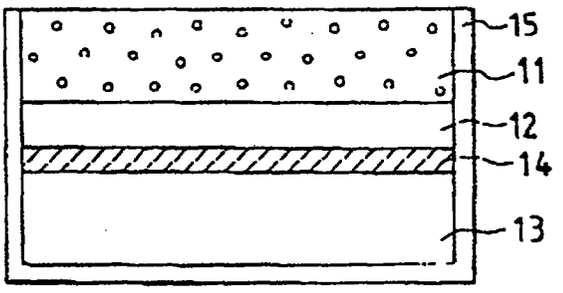


FIG. 3C

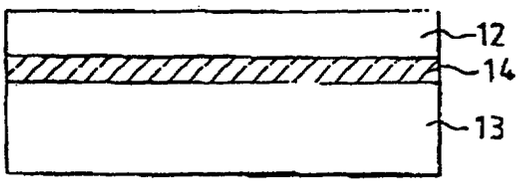


FIG. 4A

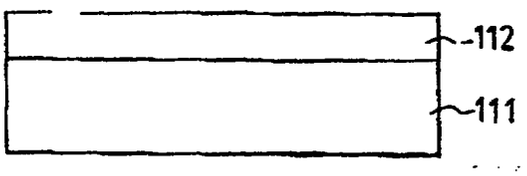


FIG. 4B

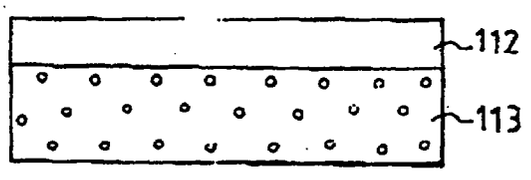


FIG. 4C

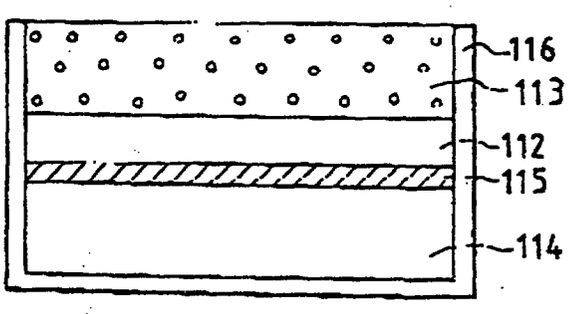
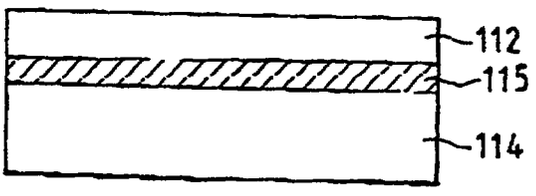


FIG. 4D



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FIG. 5A

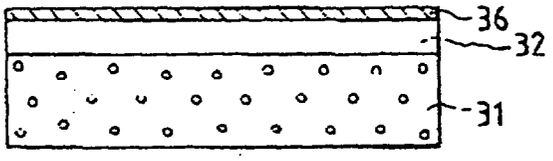


FIG. 5B

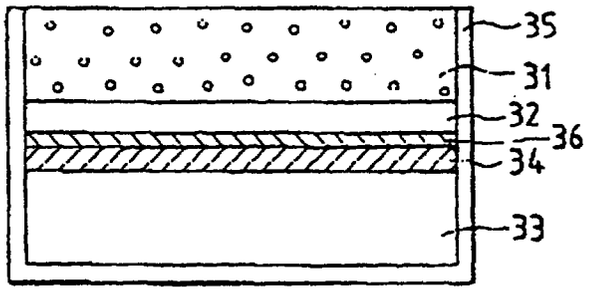


FIG. 5C

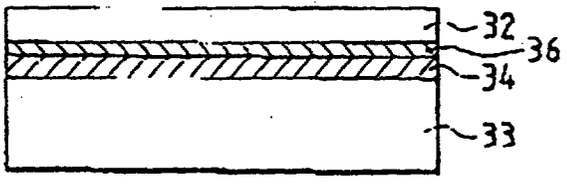


FIG. 6A

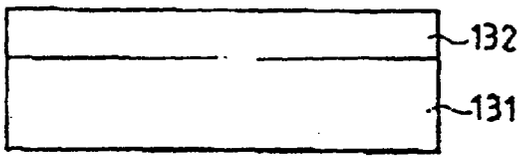


FIG. 6B

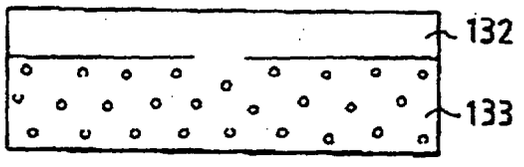


FIG. 6C

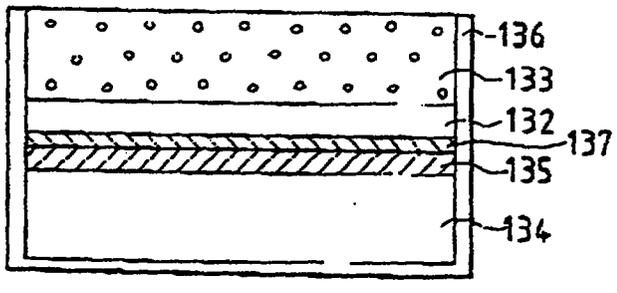
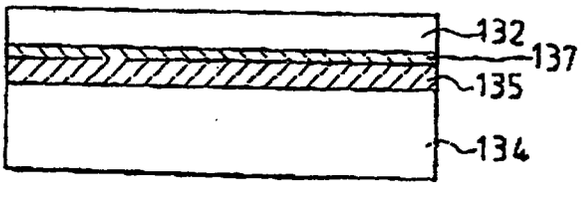


FIG. 6D



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FIG. 7A

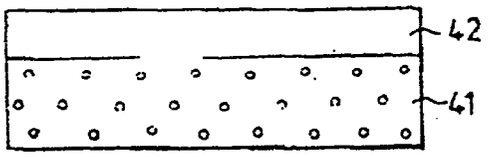


FIG. 7B

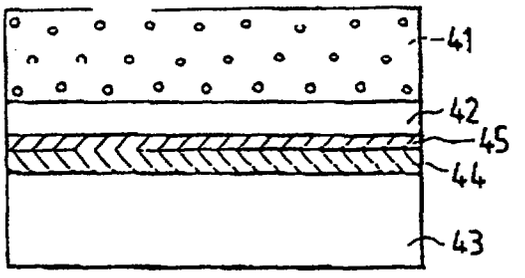


FIG. 7C

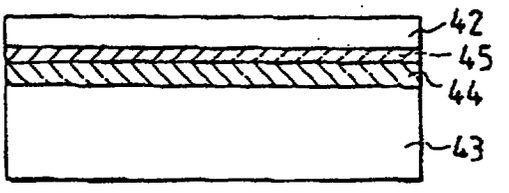


FIG. 8A

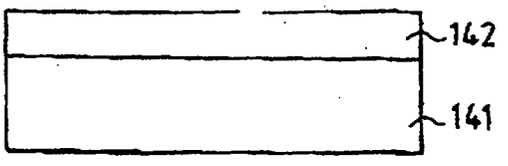


FIG. 8B

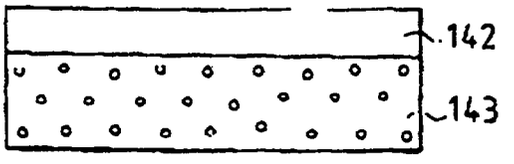


FIG. 8C

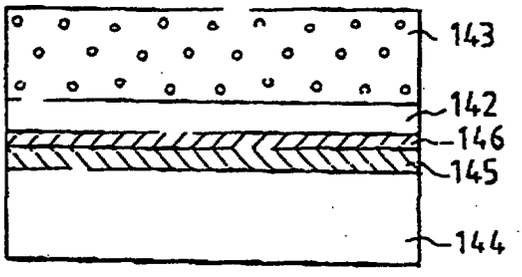
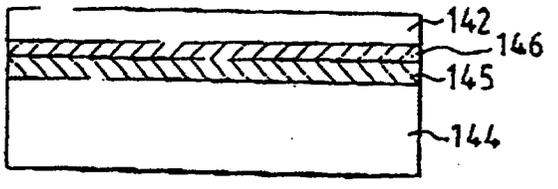


FIG. 8D



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FIG. 9A

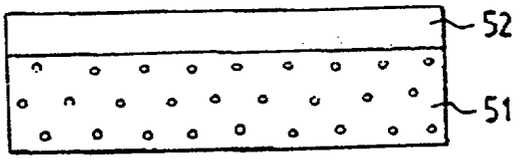


FIG. 9B

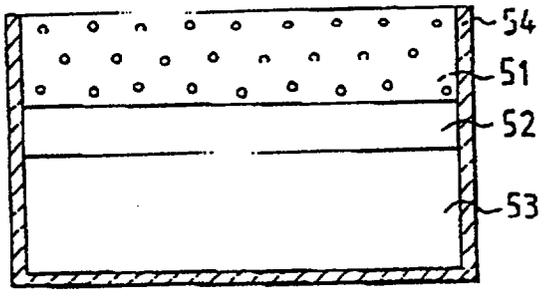


FIG. 9C

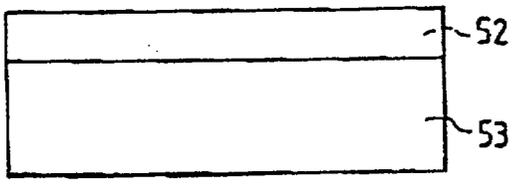


FIG. 10A

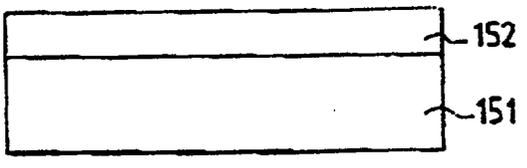


FIG. 10B

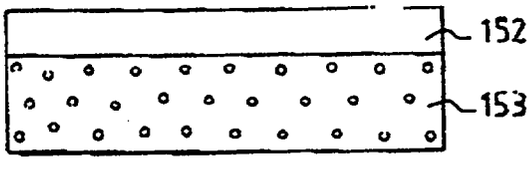


FIG. 10C

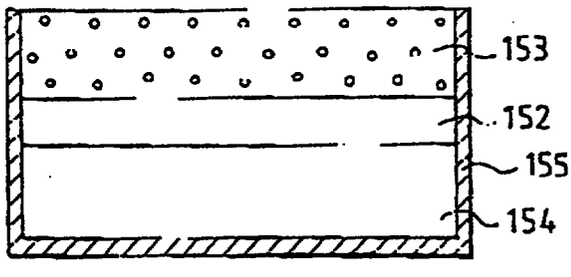
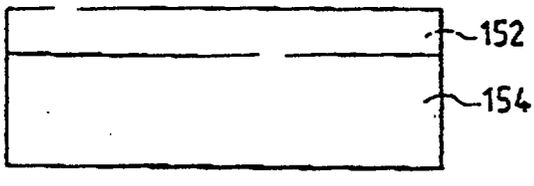


FIG. 10D



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FIG. 11A

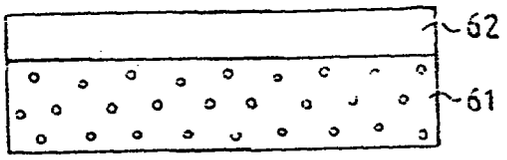


FIG. 11B

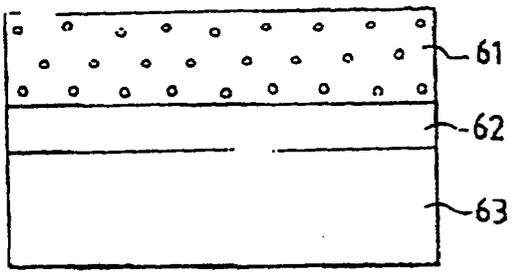


FIG. 11C

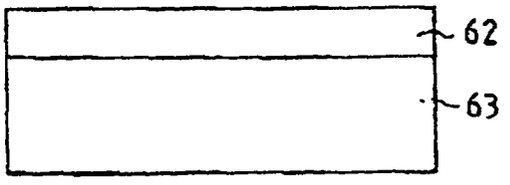


FIG. 12A

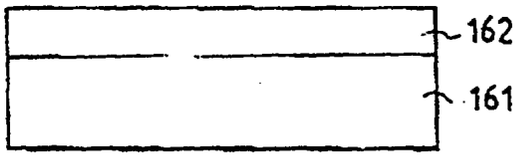


FIG. 12B

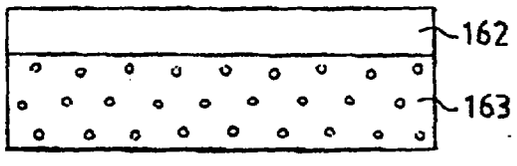


FIG. 12C

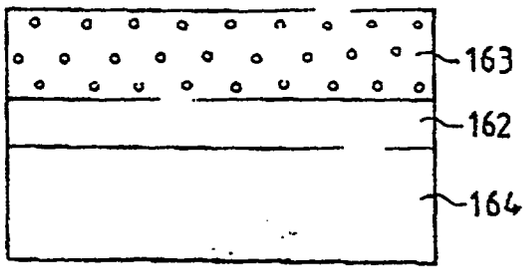
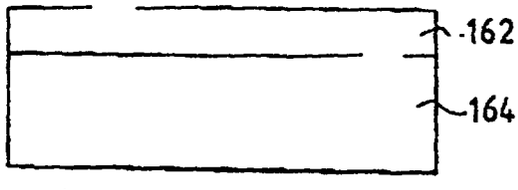


FIG. 12D



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FIG. 13A

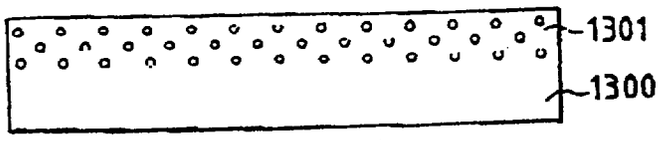


FIG. 13B

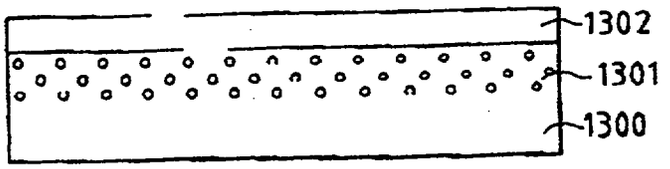


FIG. 13C

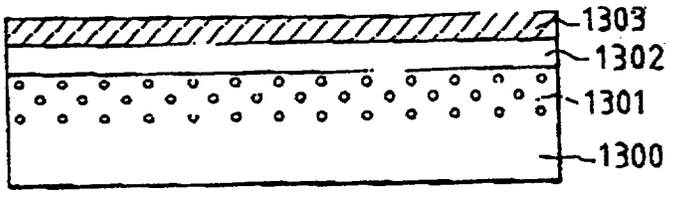


FIG. 13D

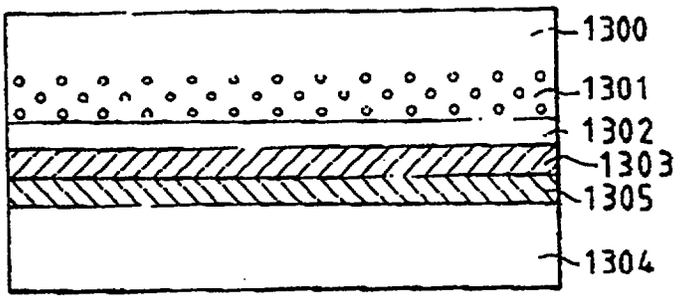


FIG. 13E

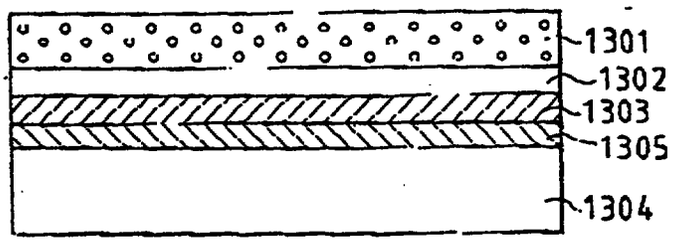
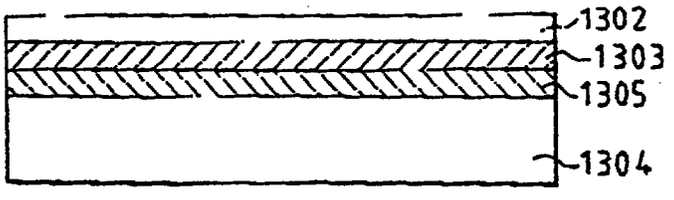


FIG. 13F



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REPLACEMENT SHEETS SG
☑ Description : paged 1 to paged 128
☑ Claim(s) : paged 129 to paged 157
☐ Drawing(s) : paged — to paged —
☑ Abstract : paged 158 to paged 158

DATE OF RECEIPT 10/12/96

Semiconductor Member and Process for Preparing Semiconductor Member

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a semiconductor member and a process for preparing a semiconductor member, more particularly to a semiconductor which is suitable for separation of dielectric materials or electronic devices, integrated circuits prepared on a monocrystalline semiconductor layer on an insulating material.

Related Background Art

Formation of a monocrystalline Si semiconductor layer on an insulating material has been widely known as the silicon on insulator (SOI) technology, and since a large number of advantages which can not be reached by bulk Si substrates for preparation of conventional Si integrated circuits are possessed by the device utilizing the SOI structure, so many researches have been done. More specifically, by utilizing the SOI structure, the following advantages can be obtained:

1. Dielectric isolation can be easily done to enable high degree of integration;

2. Radiation hardness is excellent;

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3. Stray capacity is reduced to attain high speed;

4. Well formation step can be omitted;

5. Latch-up can be prevented;

6. Fully depleted field effect transistor can be made by thin film formation.

In order to realize the many advantages in device characteristics as mentioned above, studies have been made about the method for forming the SOI structure for these some 10 years. The contents are summarized in, for example, the literature as mentioned below:

Special Issue: "Single-crystal silicon on non-single-crystal insulators"; edited by G.W. Cullen, Journal of Crystal Growth, volume 63, No.3, pp. 429 - 590 (1983).

Also, it has been known for a long time to form the SOS (silicon on sapphire) structure by heteroepitaxy of Si on a monocrystalline sapphire substrate by CVD (chemical vapor deposition) method. This was successful to some extent as the most mature SOI technique, but for such reasons as a large amount of crystal defects because of lattice mismatching at the interface between the Si layer and the sapphire substrate, introduction of aluminum from the sapphire substrate into the Si layer, and above all the high

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cost of the substrate and delay in enlargement of the substrate wafer size, it is obstructed from being widely applied. Relatively in recent years, attempts to realize the SOI structure without use of a sapphire substrate have been done. Such attempts may be broadly classified into the three shown below.

(1) After surface oxidation of a Si monocrystalline substrate, a window is formed to have the Si substrate partially exposed, and epitaxial growth is proceeded in the lateral direction with that exposed portion as the seed to form an Si monocrystalline layer on SiO_2. (In this case, deposition of Si layer on SiO_2 is accompanied).

(2) By use of a Si monocrystalline substrate itself as active layer, SiO_2 is formed therebeneath. (This method is accompanied with no deposition of Si layer).

(3) After epitaxial growth of Si on a Si monocrystalline substrate, isolation separation is effected. (This method is accompanied with deposition of Si layer).

As the means for realizing the above (1), there have been known the method in which a monocrystalline Si layer is formed directly to lateral epitaxial growth by CVD, the method in which amorphous Si is deposited and subjected to solid phase lateral

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epitaxial growth by heat treatment, the method in which amorphous or polycrystalline Si layer is irradiated convergently with an energy beam such as electron beam, laser beam, etc. and a monocrystalline layer is grown on SiO_2 by melting and recrystallization, and the method in which a melting region is scanned in a zone fashion by a rod-shaped heater (Zone melting recrystallization). These methods have both advantages and disadvantages, the still have many problems with respect to controllability, productivity, uniformity and quality, and none of them have been industrially applied yet up to date. For example, the CVD method requires sacrifice-oxidation in flat thin film formation, while the crystallinity is poor in the solid phase growth method. On the other hand, in the beam annealing method, problems are involved in controllability such as treatment time by converged beam scanning, the manner of overlapping of beams, focus adjustment, etc. Among these, the Zone Melting Recrystallization method is the most mature, and a relatively larger scale integrated circuit has been trially made, but still a large number of crystal defects such as point defect, line defect, plane defect (sub-boundary), etc. remain, and no device driven by minority carriers has been prepared.

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Concerning the method using no Si substrate as the seed for epitaxial growth which is the above method (2), for example, the following methods may be included.

1. An oxide film is formed on an Si monocrystalline substrate with V-grooves as anisotropically etched on the surface, a polycrystalline Si layer is deposited on the oxide film thick to the extent as the Si substrate, and thereafter by polishing from the back surface of the Si substrate, Si monocrystalline regions dielectrically separated by surrounding with the V-grooves on the thick polycrystalline Si layer are formed. In this method, although crystallinity is good, there are problems with respect to controllability and productivity in the step of depositing the polycrystalline Si thick as some hundred microns and the step in which the monocrystalline Si substrate is polished from the back surface to leave only the Si active layer as separated.

2. This is the method called SIMOX (Separation by ion-implanted oxygen) in which an SiO_2 layer is formed by ion implantation of oxygen into an Si monocrystalline substrate, which is one of the most mature methods because of good matching with the Si-IC

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(Integrated Circuit) process. However, for formation of the SiO_2 layer, 10^{18} ions/cm^2 or more of oxygen ions are required to be implanted, and the implantation time is very long to be not high in productivity, and also the wafer cost is high. Further, many crystal defects remin, and from an industrial point of view, no sufficient level of quality capable of preparing a device driven by minority carriers has been attained.

3. This is the method to form an SOI structure by dielectric isolation according to oxidation of porous Si. This is a method in which an N-type Si layer is formed on the surface of a P-type Si monocrystalline substrate in shape of islands by way of proton ion implantation (Imai et al., J. Crystal Growth, Vol. 63,547 (1983)), or by epitaxial growth and patterning; only the p-type Si substrate is made porous by anodization in HF solution so as to surround the Si islands from the surface; and then the N-type Si islands are dielectrically isolated by accelerated oxidation. In this method, the separated Si region is determined before the device steps, whereby there is the problem that the degree of freedom in device and circuit design may be limited in some cases.

As the method (3) as described above, the

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method described in Japanese Laid-open Patent Application No. 55-16464 has the steps of forming an N-type monocrystalline Si layer on a P-type Si wafer, providing a glass layer containing an oxide of the N-type impurity thereon and the step of bonding the glass layer to a glass layer containing the oxide of an N-purity impurity provided on another silicon wafer by heat treatment. And, subsequent to the bonding step, the P-type Si wafer is made porous, and then the porous layer is oxidized, followed by etching to remove the porous layer, thereby forming an SOI structure. Also, Japanese Patent Publication No. 53-45675 discloses a method in which a silicon monocrystalline wafer is made porous, then oxidized to make the porous layer higher in resistance; a monocrystalline Si layer is formed on the porous silicon layer; and a part of the monocrystalline Si layer is made porous and higher in resistance so as to surround the monocrystalline Si region, thereby separating the monocrystalline Si region.

The methods described in these publications all include the step of oxidizing a porous layer, and because the volume of porous layer is increased by oxidation, sometimes an influence of distortion may be exerted on the monocrystalline Si layer, and therefore in these methods, a monocrystalline Si layer with

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constantly good quality could not necessarily be formed on the insulator.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a semiconductor member capable of overcoming the problems as described above and meeting the demands as described above and a process for preparing the member.

Another object of the present invention is to provide a semiconductor having a monocrystalline layer excellent in crystallinity equally as monocrystalline SOI wafer, and a process for preparing the member excellent also in aspects of productivity, uniformity, controllability, economy.

Still another object of the present invention is to provide a semiconductor member having excellent characteristics which can be sufficiently alternative for expensive SOS or SIMOX even in preparing a large scale integrated circuit by the SOI structure and a process for preparing the member economically.

Other objects of the present invention than those as mentioned above are:

to provide a process for preparing a semiconductor member comprising the steps of:

forming a member having a non-porous monocrystalline semiconductor region on a porous

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monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and then

removing the porous monocrystalline semiconductor region by chemical etching;

to provide a process for preparing a semiconductor member comprising the steps of:

forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on the non-porous monocrystalline semiconductor side of the member, then

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the porous monocrystalline semiconductor region by chemical etching;

to provide a process for preparing a semiconductor member comprising the steps of:

making a non-porous monocrystalline semiconductor member porous to form a porous monocrystalline semiconductor region,

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forming a non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and

removing the porous monocrystalline semiconductor region by chemical etching;

to provide a process for preparing a semiconductor member comprising the steps of:

making a non-porous monocrystalline semiconductor member porous to form a porous monocrystalline semiconductor region,

forming a non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

forming region constituted of an insulating substance on the non-porous monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the porous monocrystalline semiconductor region by chemical etching;

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to provide a process for preparing a semiconductor member comprising the steps of:

making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region,

forming a third non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the third non-porous monocrystalline semiconductor region, and

removing the second non-porous monocrystalline semiconductor region mechanically, and removing the porous monocrystalline semiconductor region by chemical etching;

to provide a process for preparing a semiconductor member comprising the steps of:

making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region,

forming a third non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

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forming a region constituted of an insulating substance on the third non-porous monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the second non-porous monocrystalline semiconductor mechanically, and removing the porous monocrystalline semiconductor region by chemical etching;

to provide a process for preparing a semiconductor member comprising the steps of:

forming a second monocrystalline semiconductor region of a second electroconduction type on a first monocrystalline semiconductor region of a first electroconduction type,

making the first monocrystalline semiconductor region porous to form a porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is formed of an insulating substance onto the surface of the second monocrystalline semiconductor region, and

removing the porous monocrystalline semiconductor region by chemical etching;

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to provide a process for preparing a semiconductor member comprising the steps of:

forming a second monocrystalline semiconductor region of a second electroconduction type on a first monocrystalline semiconductor region of a first electroconduction type,

making the first monocrystalline semiconductor region porous to form a porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on the second monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is formed of an insulating substance onto the surface of the second monocrystalline semiconductor region, and

removing the porous monocrystalline semiconductor region by chemical etching;

to provide a semiconductor member comprising:

a first member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region, and

a second member having the surface constituted of an insulating substance bonded onto the surface of the non-porous monocrystalline semiconductor region;

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to provide a semiconductor member comprising:

a first member having a non-porous monocrystalline semiconductor region and a region constituted of an insulating substance arranged in this order on a porous monocrystalline semiconductor region, and

a second member bonded through a region constituted of an insulating substance onto the surface of the region constituted of the insulating substance;

to provide a semiconductor member having a non-porous silicon monocrystalline semiconductor region arranged on a region constituted of an insulating substance, characterized in that the dislocation defect density in the non-porous silicon monocrystalline semiconductor region is $2.0 \times 10^4/cm^2$ or less, and the life time of carriers is 5.0×10^{-4} second or longer; and

to provide a semiconductor member having a non-porous silicon monocrystalline semiconductor region arranged on a region constituted of an insulating substance, characterized in that the dislocation defect density in the non-porous silicon monocrystalline semiconductor region is $2.0 \times 10^4/cm^2$ or less, and the life time of carriers is 5.0×10^{-4} sec or longer, and also the difference between the

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maximum value and the minimum value of the thickness of the silicon monocrystalline semiconductor region is 10% or less with respect to maximum value.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1 through 13 are schematic illustrations of the examples of the steps of the process for preparing the semiconductor member of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferable semiconductors of the present invention are as described below.

A semiconductor member of the present invention comprises:

a first member having a non-porous monocrystalline semiconductor region provided on a porous monocrystalline semiconductor region, and

a second member having the surface constituted of an insulating substance bonded onto the surface of the non-porous monocrystalline semiconductor region.

Another semiconductor member comprises:

a first member having a non-porous monocrystalline semiconductor region and a region constituted of an insulating substance arranged in this order on a porous monocrystalline semiconductor region, and

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a second member bonded through a region constituted of an insulating substance onto the surface of the region constituted of the insulating substance.

Still another semiconductor member has a non-porous silicon monocrystalline semiconductor region arranged on a region constituted of an insulating substance, wherein the dislocation defect density in the non-porous silicon monocrystalline semiconductor region is $2.0 \times 10^4/cm^2$ or less, and the life time of carriers is 5.0×10^{-4} sec or longer.

Still another semiconductor member has a non-porous silicon monocrystalline semiconductor region arranged on a region constituted of an insulating substance, wherein the dislocation defect density in the non-porous silicon monocrystalline semiconductor region is $2.0 \times 10^4/cm^2$ or less, and the life time of carriers is 5.0×10^{-4} sec or longer, and also the difference between the maximum value and the minimum value of the thickness of the silicon monocrystalline semiconductor region is 10% or less, with respect to the maximum value.

Preferable processes for preparing the semiconductor member of the present invention are as described below.

A process for preparing a semiconductor member

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of the present invention comprises:

forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and then

removing the porous monocrystalline semiconductor region by chemical etching.

Another process comprises:

forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

forming a region constituted of an insulting substance on the non-porous monocrystalline semiconductor side of the member, then

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the porous monocrystalline semiconductor region by chemical etching.

Still another process comprises:

making a non-porous monocrystalline semiconductor member porous to form a porous

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monocrystalline semiconductor region,

forming a non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and

removing the porous monocrystalline semiconductor region by chemical etching.

Still another process comprises the steps of:

making a non-porous monocrystalline semiconductor member porous to form a porous monocrystalline semiconductor region,

forming a non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on the non-porous monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the porous monocrystalline semiconductor region by chemical etching.

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Still another process comprises the steps of:

making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region,

forming a third non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the third non-porous monocrystalline semiconductor region, and

removing the second non-porous monocrystalline semiconductor region by mechanical grinding, and removing the porous monocrystalline semiconductor region by chemical etching.

Still another process comprises the steps of:

making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region,

forming a third non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on the third non-porous monocrystalline

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semiconductor region side,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the second non-porous monocrystalline semiconductor by mechanical grinding, and removing the porous monocrystalline semiconductor region by chemical etching.

Still another process comprises the steps of:

forming a second monocrystalline semiconductor region of a second conduction type on a first monocrystalline semiconductor region of a first conduction type,

making the first monocrystalline semiconductor region porous to form a porous monocrystalline semiconductor region,

forming a region constituted of an insulating material on the second monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the second monocrystalline semiconductor region, and

removing the porous monocrystalline semiconductor region by chemical etching.

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Still another process comprises the steps of:

forming a second monocrystalline semiconductor region of a second electroconduction type on a first monocrystalline semiconductor region of a first electroconduction type,

making the first monocrystalline semiconductor region porous to form a porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on the second monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is formed of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the porous monocrystalline semiconductor region by chemical etching.

The semiconductor member of the present invention has a monocrystalline semiconductor region where carrier life time is long and the defect is extremely little on an insulating material with excellent uniformity of thickness, and is applicable to various semiconductor devices. Also, the semiconductor member of the present invention is capable of high speed response, and is applicable to semiconductor devices rich in reliability. The

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semiconductor member of the present invention can be also an alternative for expensive SOS or SIMOX.

The process for preparing a semiconductor member of the present invention provides a process excellent in aspects of productivity, uniformity, controllability, economy in obtaining an Si crystal layer having crystallinity equal to monocrystalline wafer on an insulating material.

Further, according to the process for preparing a semiconductor member of the present invention, it is possible to provide semiconductor members wherein the advantages of the SOI device of the prior art can be realized and applied.

Also, according to the present invention, there can be provided a process for preparing a semiconductor member which can be an alternative for expensive SOS or SIMOX also in preparing a large scale integrated circuit of SOI structure.

The process for preparing a semiconductor member of the present invention, as is described in detail in Examples, makes it possible to perform the treatment efficiently within a short time, and is excellent in its productivity and economy.

Referring now to silicon as an example of semiconductor materials, the present invention is described in detail, but the semiconductor material in

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the present invention is not limited to silicon at all.

In porous Si layer, according to observation by transmission electron microscopy, pores with diameters of about 600 angstroms on an average are formed, and despite the fact that their density is half or lower as compared with monocrystalline silicon, momocrystallinity is maintained. Monocrystal refers to a crystalline solid such that, when calling attention on an optional crystal axis, its direction is the same at any part of the sample, and the porous layer used in the present invention, although having pores therethrough, the crystal axis in the crystalline region is the same in the direction at any part, thus being monocrystalline. And, epitaxial growth of a monocrystalline Si layer onto the porous layer is possible. However, at a temperature of 1000 ^{o}C or higher, rearrangement of the atoms positioned around the inner pores takes place, whereby the characteristics of accelerated chemical etching may be sometimes impaired. For this reason, in the present invention, for epitaxial growth of Si layer, there may be suitably used the crystal growth method capable of low temperature growth such as molecular beam epitaxial growth, plasma CVD, low pressure CVD method, photo CVD, bias-sputtering method, liquid phase growth

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method, etc.

Since the porous layer has a large amount of voids formed internally thereof, its density can be reduced to half or lower. As the result, the surface area per unit volume (specific surface area) can be dramatically increased, and therefore its chemical etching rate is remarkably accelerated as compared with that of the etching rate of conventional non-porous monocrystalline layer. The present invention utilizes the two above-mentioned characteristics of the semiconductor as made porous, namely the fact that single crystallinity is maintained and a non-porous semiconductor monocrystal can therefore be epitaxially grown on the semiconductor substrate as made porous, and the fact that etching rate is remarkably more rapid as compared with non-porous monocrystal, whereby a non-porous semiconductor monocrystalline layer of high quality can be formed on a substrate having an insulating material surface within a short time.

The porous layer can be more readily formed on a P-type Si layer than an N-type Si layer for the following reason. First, a porous Si was discovered by Uhlir et al. in the research process of electrolytic polishing of semiconductor in 1956 (A. Uhlir, Bell Syst. Tech. J., vol 35, p.333 (1956)).

Unagami et al. studied about the dissolving

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reaction of Si in anodization, and has reported that positive holes are necessary for the anodic reaction of Si in an HF solution, and the reaction is as follows (T. Unagami, J. Electrochem. Soc., vol. 127, p. 476 (1980)).

$$Si + 2HF + (2-n)e^{+} \longrightarrow SiF_2 + 2H^{+} + ne^{-}$$

$$SiF_2 + 2HF \longrightarrow SiF_4 + H_2$$

$$SiF_4 + 2HF \longrightarrow H_2SiF_6$$

or

$$Si + 4HF + (4 - \lambda)e^{+} \longrightarrow SiF_4 + 4H^{+} + \lambda e^{-}$$

$$SiF_4 + 2HF \longrightarrow H_2SiF_6.$$

Here, e^{+} and e^{-} represent a positive hole and an electron, respectively. n and λ are respectively numbers of positive holes necessary for dissolving one atom of silicon, and it has been postulated that porous silicon is formed when satisfying the condition of $n > 2$ or $\lambda > 4$.

For the reasons mentioned above, the P-type silicon in which positive holes exist will be more readily made porous than the N-type silicon of the opposite characteristic. Selectivity in such pore structure formation has been verified by Nagano et al. (Nagano, Nakajima, Yasuno, Ohnaka, Kajiwara; Denshi Tsushin Gakkai Gijutsu Kenkyu Hokoku, vol. 79, SSD 79-9549(1979)) and Imai, (K. Imai; Solid-State Electronics vol. 24, 159 (1981)). However, depending

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on the conditions, the N-type silicon can be also made porous.

Referring now to the drawings, the present invention is described in more detail.

Embodiment 1

Description is made about the process for obtaining a semiconductor substrate by making porous all of a P-type substrate and permitting a monocrystalline layer to be epitaxially grown.

As shown in Fig. 1A, first a P-type Si monocrystalline substrate is provided, and all of it is made porous. According to the crystal growth method capable of low temperature growth as mentioned above, epitaxial growth is effected on the substrate surface as made porous to form a thin film monocrystalline layer 22. The above P-type Si substrate is made porous by the anodization method by use of an HF solution. The porous Si layer 21 can be varied in its density to a range of 1.1 to 0.6 g/cm^3 by varying the HF solution concentration to 50 to 20% as compared with the density 2.33 g/cm^3 of the monocrystalline Si.

Subsequently, as shown in Fig. 1B, by providing another Si substrate 23 and after forming an oxidized layer 24 on its surface, the Si substrate 23 having the oxidized layer 24 on the surface is bonded

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onto the surface of the monocrystalline layer 22 on the porous Si substrate 21. Then, as shown in Fig. 1C, the porous Si substrate 21 is all etched away to form a thin film-like monocrystalline silicon layer 22 remaining on the SiO_2 layer 24. In the present invention, since the porous semiconductor layer is etched away without application of the oxidation treatment on the porous semiconductor layer, the oxidation swelling of the porous semiconductor layer can be prevented, whereby the influence of distortion on the monocrystalline layer as epitaxially grown can be prevented. According to this method, the monocrystalline Si layer 22 equal to silicon wafer in crystallinity is formed flat and yet uniformly thinly over the whole wafer region with a large area on the oxidized Si layer 24 which is an insulating material. The semiconductor substrate thus obtained can be suitably used also with respect to preparation of an insulation separated electronic device.

Here, the thickness of the non-porous semiconductor crystalline layer to be formed on the porous semiconductor substrate may be desirably made preferably 50 μm or less, more preferably 20 μm or less, for forming a thin film semiconductor device on the above semiconductor monocrystalline layer.

Bonding between the above non-porous

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semiconductor monocrystal and the substrate having the insulating material surface should be preferably performed in an atmosphere of nitrogen, an inert gas or a gas mixture of these, or in an atmosphere containing an inert gas or nitrogen, and further desirably under heated state.

As the etchant for selectively etching the above semiconductor substrate as made porous with the above non-porous semiconductor monocrystalline layer as bonded onto the substrate having the insulating material surface being left to remain, for example, there may be employed etchants such as aqueous sodium hydroxide solution, aqueous potassium hydroxide solution, hydrofluoric acid-nitric acid-acetic acid mixed solution, etc.

The substrate having an insulating material which can be used in the present invention may be one with at least its surface being constituted of an insulating material, or one with all of the substrate being constituted of an insulating material. Examples of the substrate with the surface being constituted of an insulating material may include monocrystalline or polycrystalline silicon substrates having the surface oxidized, electroconductive or semiconductive substrates having a layer of an insulating material such as oxide, nitride, boride, etc. formed on the

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surface, etc. Specific examples of the substrates wholly constituted of an insulating material may include substrates comprising insulating materials such as fused silica glass, sintered alumina, etc.

Meanwhile, in the present Embodiment 1, an example of forming a non-porous semiconductor monocrystalline layer on a porous semiconductor substrate has been shown, but the present invention is not limited only to the mode of the Embodiment 1 as described above, but a porous semiconductor substrate having a non-porous semiconductor monocrystalline layer may be also formed by applying a pore forming treatment on a substrate having a monocrystalline layer comprising a material which can be made porous with difficulty (e.g. N-type silicon) and a layer comprising a material which can be readily made porous (e.g. P-type silicon).

Also, in the step of removing the porous semiconductor substrate by etching, the substrate may be also coated with an etching preventive material except for the porous semiconductor substrate during etching, so that the non-porous semiconductor monocrystalline layer and the substrate having the insulating material surface may not be deleteriously influenced by the etchant.

The non-porous monocrystalline layer on the

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insulating material thus formed can be one having 5.0 x 10^{-4} sec. or longer in terms of the life time of carriers, having remarkably less crystal defect such as through dislocation, etc. and also being extremely small in distribution of the layer thickness of the semiconductor monocrystalline layer. Specifically, the dislocation defect density becomes 2 x $10^{4}/cm^{2}$ or less, and concerning the layer thickness of the semiconductor monocrystalline layer, within the range of the area of the semiconductor monocrystalline layer from 20 cm^{2} to 500 cm^{2} (2 inches wafer to 10 inches wafer), the difference between the maximum value and the minimum value of the thickness of the semiconductor monocrystalline layer can be suppressed below 10% or less based on the maximum value.

In the following, other embodiments are shown.

Embodiment 2

Referring now to Figs. 2A to 2D, Embodiment 2 is described in detail.

First, as shown in Fig. 2A, a low impurity concentration layer 122 is formed by epitaxial growth according to various thin film growth methods. Alternatively, protons may be ion implanted into the surface of the P-type Si monocrystalline substrate 121 to form an N-type monocrystalline layer 122.

Next, as shown in Fig. 2B, the back surface of

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the P-type monocrystalline substrate 121 is denatured into a porous Si substrate 123 according to the anodization method by use of an HF solution. The porous Si layer 123 can be varied in its density to a range of 1.1 to 0.6 g/cm^3 by varying the HF solution concentration within the range of 50 to 20% as compared with the density of the monocrystalline Si of 2.33 g/cm^3. The porous layer, as described above, is formed on the P-type substrate.

As shown in Fig. 2C, by providing another Si substrate 124 and after forming an oxidized layer 125 on its surface, the Si substrate 124 having the oxidized layer 125 on its surface is bonded to the surface of the monocrystalline Si layer 122 on the porous Si substrate 123.

Then, the porous Si substrate 123 is all etched to leave a monocrystalline silicon layer 122 as thin film on the SiO_2 layer 125, thereby forming a semiconductor substrate.

According to this process, the monocrystalline Si layer 122 equal in crystallinity to silicon wafer is formed on the oxidized layer 125 which is an insulating material to be flat and to be yet made uniformly into thin layer, over the whole wafer region with a large area.

The semiconductor substrate thus obtained can

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be used suitably also with respect to preparation of an insulation separated electronic device.

The above Embodiment 2 is an example of the process of forming an N-type layer on a P-type substrate before pore formation, and then making selectively only the P-type substrate porous by anodization. Also in the present Embodiment, a semiconductor substrate having a semiconductor monocrystalline layer with the same performances as Embodiment 1 can be obtained.

Embodiment 3

As shown in Fig. 3A, first a P-type Si monocrystalline substrate is prepared and all of it is made porous. According to various growth methods, epitaxial growth is effected on the substrate surface made porous to form a thin film monocrystalline layer 12.

As shown in Fig. 3B, by preparing another Si substrate 13 and after forming an oxidized layer 14 on its surface, the Si substrate having the oxidized layer 14 on the surface is bonded to the surface of the monocrystalline Si layer 12 on the porous Si substrate 11.

Next, as shown in Fig. 3B, an Si_3N_4 layer 15 is deposited to cover over the whole of the bonded two silicon wafers as the anti-etching film.

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Subsequently, as shown in Fig. 3C, the Si_3N_4 layer on the surface of the porous silicon substrate is removed. As another anti-etching film material, Apiezon Wax may be also employed in place of Si_3N_4. Then, the porous Si substrate 11 is all etched and a monocrystalline silicon layer 12 made into a thin film remains on the SiO_2 layer 14 to form a semiconductor substrate.

Fig. 3C shows a semiconductor substrate obtained in the present invention. More specifically, by removing the Si_3N_4 layer 15 as the anti-etching film in Fig. 3B, a monocrystalline Si layer 12 of which crystallinity is equal to that of bulk wafer is formed through the SiO_2 layer 14 which is an insulating substance on the Si substrate 13, flat and yet uniformly into a thin layer, over the whole wafer region with a large area. The semiconductor substrate thus obtained can be used suitably also with respect to preparation of a discrete insulated electronic device. Also in the present Embodiment, a semiconductor substrate having a semiconductor monocrystalline layer with the same performances as Embodiment 1 can be obtained.

Embodiment 4

Referring now to Figs. 4A to 4B, the Embodiment 4 of the present invention is described

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below in detail.

First, as shown in Fig. 4A, a low impurity concentration layer 112 is formed by epitaxial growth according to various thin film growth methods. Alternatively, protons may be ion-implanted into the surface of the P-type Si monocrystalline substrate 111 to form an N-type monocrystalline layer 112.

Next, as shown in Fig. 4B, the back surface of the P-type monocrystalline substrate 111 is denatured into a porous Si substrate 113 according to the anodization method by use of an HF solution. The porous Si layer 113 can be varied in its density to a range of 1.1 to 0.6 g/cm^3 by varying the HF solution concentration to 50 to 20% as compared with the density of the monocrystalline Si of 2.33 g/cm^3. The porous layer 113, as described above, is formed from the P-type substrate.

As shown in Fig. 4C, by preparing another Si substrate 114 and after forming an oxidized layer 115 on its surface, the Si substrate 114 having the oxidized layer 115 on the surface is bonded on the surface of the monocrystalline Si layer 112 on the porous Si substrate 113.

Here, as shown in Fig. 4C, as the anti-etching film 116, an Si_3N_4 layer 116 is deposited to cover over the whole of the bonded two silicon wafers as the

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anti-etching film. Subsequently, as shown in Fig. 4C, the Si_3N_4 layer on the surface of the porous silicon substrate is removed. As another anti-etching film 116, a material excellent in etching resistance such as Apiezon Wax may be also employed in place of Si_3N_4. Then, the porous Si substrate 113 is all etched to form a semiconductor substrate by retaining a monocrystalline silicon layer 112 made into a thin film on the SiO_2 layer 115. Fig. 4D shows a substrate having the semiconductor layer obtained in the present invention. That is, by removing the Si_3N_4 layer 116 as the anti-etching film 116 shown in Fig. 4C, a monocrystalline Si layer 112 is formed on the SiO_2 layer 115 which is the insulating material, flat and yet uniformly into a thin layer, over the whole wafer region with a large area.

The semiconductor thus obtained will not be deleteriously affected by the etchant, and can be used suitably also with respect to preparation of a discrete insulated electronic device.

Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 5

As shown in Fig. 5A, first, a P-type Si monocrystalline substrate is prepared and all of it is

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made porous. A thin film monocrystalline layer 32 is formed by effecting epitaxial growth on the substrate surface made porous according to various growth methods.

As shown in Fig. 5B, by preparing another Si substrate 33 and after forming an oxidized layer 34 on its surface, the Si substrate 33 having the oxidized layer 34 on the surface is bonded to the surface of the oxidized layer 36 formed on the monocrystalline Si layer 32 on the porous substrate 31. The bonding step is practiced by closely contacting the cleaned surfaces with each other, followed by heating in an inert gas atmosphere or nitrogen atmosphere. The oxidized layer 34 is formed in order to reduce the interface level of the non-porous monocrystalline layer 32 which is the final active layer. As shown in Fig. 5B, an Si_3N_4 layer 35 is deposited as the anti-etching film to be coated on the bonded two silicon wafers as a whole. Subsequently, as shown in Fig. 5C, the Si_3N_4 layer 35 on the surface of the porous silicon substrate 31 is removed. As another anti-etching film material, Apiezon Wax, etc. may be also employed in place of Si_3N_4. Then, all of the porous Si substrate 31 is etched to have the monocrystalline silicon layer 32 made into a thin film remain on the SiO_2 layer, thereby forming a semiconductor substrate.

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Fig. 5C shows the substrate having the semiconductor layer obtained in the present invention. More specifically, by removing the Si_3N_4 layer 35 as the anti-etching film shown in Fig 5B, the monocrystalline Si layer 32 equal in crystallinity to silicon wafer is formed through the SiO_2 layers 34 and 36 on the Si substrate 33, flat and yet uniformly into a thin layer, over the whole wafer region with a large area. The semiconductor substrate thus obtained can be used suitably also with respect to preparation of a discrete insulated electronic device. Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 6

Referring now to Figs. 6A to 6D, the Embodiment 6 of the present invention is described below in detail.

First, as shown in Fig. 6A, a low impurity concentration layer 132 is formed by epitaxial growth according to various thin film growth methods. Alternatively, the surface of the P-type Si monocrystalline substrate 131 is subjected to ion implantation of protons to form an N-type monocrystalline layer 132.

Next, as shown in Fig. 6B, the P-type Si

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monocrystalline substrate 131 is denatured from the back surface to a porous Si substrate 133 by the anodization method with an HF solution. The porous Si layer 133 can be varied in its density in the range of 1.1 to 0.6 g/cm^3 by varying the HF solution concentration to 50 to 20% as compared with the density of the monocrystalline Si of 2.33 g/cm^3. The porous layer, as described above, is formed from the P-type substrate.

As shown in Fig. 6C, by preparing another Si substrate 134 and after forming an oxidized layer 135 on its surface, the Si substrate 134 having the oxidized layer 135 is bonded onto the surface of the oxidized layer 137 formed on the monocrystalline Si layer 132 on the porous Si substrate 133.

Subsequently, as the anti-etching film 136, an Si_3N_4 layer 136 is deposited to be coated on the bonded two silicon wafers as a whole. Then, as shown in Fig. 6D, the Si_3N_4 layer 136 on the surface of the porous silicon substrate 133 is removed. Then the porous Si substrate 131 is all chemically etched to have a monocrystalline silicon layer made into a thin film remain on the SiO_2 layers 135 and 137, thereby forming a semiconductor substrate.

The semiconductor substrate thus obtained is excellent in adhesion between the respective layers,

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and can be also used suitable also with respect to preparation of an isolation separated electronic device. Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 7

As shown in Fig. 7A, first, a P-type Si monocrystalline substrate is prepared and all of it is made porous. According to various growth methods, epitaxial growth is effected on the substrate surface made porous to form a thin film monocrystalline layer 42. As shown in Fig. 7B, by preparing another Si substrate 43 and after forming an oxidized layer 44 on its surface, the Si substrate 43 having the above oxidized layer 44 on the surface is bonded onto the surface of the oxidized layer 45 formed on the monocrystalline Si layer 42 on the porous Si substrate 41. This bonding step is practiced by closely contacting cleaned surfaces with each other, followed by heating in an inert gas atmosphere or nitrogen atmosphere. The oxidized layer 44 is formed in order to reduce the interface level of the monocrystalline layer 42 which is the active layer as the final semiconductor. As shown in Fig. 7C, the porous Si substrate 41 is all etched to have the monocrystalline silicon layer made into a thin film on the SiO_2 layers

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44 and 45, thereby forming a semiconductor substrate. Fig. 7C shows the semiconductor substrate obtained in the present invention.

A monocrystalline Si layer 42 equal in crystallinity to silicon wafer is formed through the SiO_2 layers 44 and 45 on the Si substrate 43, flat and yet uniformly into a thin layer, over the whole wafer region with a large area. The semiconductor substrate thus obtained can be also used suitably also as seen from the standpoint of preparation of an isolation separated electron device. Also, the semiconductor substrate obtained in the present embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 8

Referring now to Figs. 8A to 8D, the Embodiment 8 of the present invention is described below in detail.

First, as shown in Fig. 8A, a low impurity concentration layer 142 is formed by epitaxial growth according to various thin film growth methods. Alternatively, the surface of the P-type Si monocrystalline substrate 141 is subjected to ion implantation of protons to form an N-type monocrystalline layer 142.

Next, as shown in Fig. 8B, the P-type Si monocrystalline substrate 141 is denatured from the

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back surface to a porous Si substrate 143 by the anodization method with an HF solution. The porous Si layer 143 can be varied in its density in the range of 1.1 to 0.6 g/cm^3 by varying the HF solution concentration to 50 to 20% as compared with the density of the monocrystalline Si of 2.33 g/cm^3. The porous layer, as described above, is formed on the P-type substrate 141.

As shown in Fig. 8C, by preparing another Si substrate 144 and after forming an oxidized layer 145 on its surface, the Si substrate 144 having the oxidized layer 145 is bonded onto the surface of the oxidized layer 146 formed on the monocrystalline Si layer 142 on the porous Si substrate 143.

Then the porous Si substrate is all chemically etched to have a monocrystalline silicon layer made into a thin film remain on the SiO_2 layers 145 and 146, thereby forming a semiconductor substrate.

Fig. 8D shows the semiconductor substrate obtained in the present invention. A monocrystalline Si layer 142 equal in crystallinity to silicon wafer is formed through the SiO_2 layers 145 and 146 on the Si substrate 144, flat and yet uniformly into a thin layer, over the whole wafer region with a large area.

The semiconductor substrate thus obtained can be also used suitably also with respect to preparation

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of an isolation separated electronic device. Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 9

As shown in Fig. 9A, first, a P-type Si monocrystalline substrate is prepared, and all of it is made porous. According to various growth methods, epitaxial growth is effected on the surface of the substrate 51 made porous to form a thin film monocrystalline layer 52.

As shown in Fig. 9B, a light-transmissive substrate 53 represented by glass is prepared and the light-transmissive substrate 53 is bonded onto the surface of the monocrystalline Si layer 52 on the porous Si substrate 51.

Here, as shown in Fig. 9B, as the anti-etching film 54, an Si_3N_4 layer 54 is deposited to be coasted on the bonded two substrates as a whole.

Subsequently, as shown in Fig. 9C, the Si_3N_4 layer 54 on the surface of the porous silicon substrate is removed. Then, the porous Si substrate 51 is all etched away to have a monocrystalline silicon layer 52 made into a thin film remain on the light-transmissive substrate 53, thereby forming a semiconducor substrate. Fig. 9C shows the semiconductor substrate

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obtained in the present invention.

The semiconductor substrate thus obtained can be also used suitable also as seen from the standpoint of preparation of an electronic device isolation separated with a light-transmissive insulating material. Also, the semiconductor obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 10

Referring now to Figs. 10A to 10D, the Embodiment 10 of the present invention is described below in detail.

First, as shown in Fig. 10A, a low impurity concentration layer 152 is formed by epitaxial growth according to various thin film growth methods. Alternatively, the surface of the P-type Si monocrystalline substrate 151 is subjected to ion implantation of protons to form an N-type monocrystalline layer 152.

Next, as shown in Fig. 10B, the P-type Si monocrystalline substrate 151 is denatured from the back surface to a porous Si substrate 153 by the anodization method with an HF solution. The porous Si layer 153 can be varied in its density in the range of 1.1 to 0.6 g/cm^3 by varying the HF solution concentration to 50 to 20% as compared with the

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density of the monocrystalline Si of 2.33 g/cm^3. The porous layer 153, as described above, is formed on the P-type substrate 151.

As shown in Fig. 10C, after preparing a light-transmissive substrate 154, onto the surface of the monocrystalline Si layer 152 on the porous Si substrate 153 is bonded the light-transmissive substrate 154. Then, as shown in Fig. 10C, as an anti-etching film 155, an Si_3N_4 layer, etc. is deposited to be coated on the bonded two substrates as a whole. Subsequently, as shown in Fig. 10D, the Si_3N_4 layer 155 on the surface of the porous silicon substrate 153 is removed. Then, the porous Si substrate 153 is all etched away to have the monocrystalline silicon layer 152 made into a thin film remain on the light-transmissive substrate 154, thereby forming a semiconductor substrate.

Fig. 10D shows the semiconductor substrate obtained in the present invention. It is the monocrystalline Si layer 152 equal in crystallinity to silicon wafer formed on the light-transmissive substrate 154, flat and yet uniformly into a thin layer, over the whole wafer region with a large area.

The semiconductor substrate thus obtained can be also used suitably also with respect to preparation of an isolation separated electronic device with a

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light-transmissive insulating material. Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 11

As shown in Fig. 11A, first, a P-type Si monocrystalline substrate is prepared, and all of it is made porous. According to various growth methods, epitaxial growth is effected on the surface of the substrate 61 made porous to form a thin film monocrystalline layer 62.

As shown in Fig. 11B, a light-transmissive substrate 63 represented by glass is prepared and the light-transmissive substrate 63 is bonded to the surface of the monocrystalline Si layer 62 on the porous Si substrate 61.

Then, the porous Si substrate 61 is all etched to have the monocrystalline silicon layer 62 made into a thin film remain on the light-transmissive substrate 63, thereby forming a semiconductor substrate.

Fig. 11C shows the semiconductor substrate obtained in the present invention. It is the monocrystalline Si layer 62 equal in crystallinity to silicon wafer formed on the light-transmissive substrate 63, flat and yet uniformly into a thin layer, over the whole wafer region with a large area.

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The semiconductor thus obtained can be also suitably used also with respect to preparation of an electronic device isolation separated with a light-transmissive insulating material.

Embodiment 12

Referring now to Figs. 12A to 12D, the Embodiment 12 of the present invention is described below in detail.

First, as shown in Fig. 12A, a low impurity concentration layer 162 is formed by epitaxial growth according to various thin film growth methods. Alternatively, the surface of the P-type Si monocrystalline substrate 161 is subjected to ion implantation of protons to form an N-type monocrystalline layer 162.

Next, as shown in Fig. 12B, the P-type Si monocrystalline substrate 161 is denatured from the back surface to a porous Si substrate 163 by the anodization method with an HF solution. The porous Si layer 163 can be varied in its density in the range of 1.1 to 0.6 g/cm^3 by varying the HF solution concentration to 50 to 20% as compared with the density of the monocrystalline Si of 2.33 g/cm^3. The porous layer 163, as described above, is formed on the P-type substrate 163.

As shown in Fig. 12C, after preparing a light-

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transmissive substrate 164, onto the surface of the monocrystalline Si layer 162 on the porous Si substrate 163 is bonded the light-transmissive substrate 164. As shown in Fig. 12C, the porous Si substrate 163 is all etched away to have the monocrystalline silicon layer 162 made into a thin film remain on the light-transmissive substrate 164, thereby forming a semiconductor substrate.

Fig. 12D shows the semiconductor substrate obtained in the present invention. It is the monocrystalline Si layer 162 equal in crystallinity to silicon wafer formed on the light-transmissive substrate 164, flat and yet uniformly into a thin layer, over the whole wafer region with a large area.

The semiconductor substrate thus obtained can be also used suitably also with respect to preparation of an isolation separated electronic device with a light-transmissive insulating material. Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

Embodiment 13

This Embodiment is described by referring to Figs. 13A to 13F. As shown in Fig. 13A, first a porous region 1301 is formed on a part of an Si monocrystalline substrate 1300. Subsequently, a thin

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film Si monocrystalline layer 1302 is formed according to various crystal growth methods on the porous region 1301 (Fig. 13B). On the thin film Si monocrystalline layer 1302 is formed an oxidized film 1303 (Fig. 13C).

The oxidized film 1305 formed on the surface of another Si substrate 1304 is bonded to the above oxidized film 1303 (Fig. 13D).

Subsequently, the Si monocrystalline substrate 1300 remaining without being made porous is removed by mechanical polishing or etching to have the porous region 1301 exposed (Fig. 13E).

The porous region 1301 is etched away to form a semiconductor substrate having a thin film Si monocrystalline layer on an insulating material (Fig. 13F).

When such step is employed, the time required for making the substrate porous can be shortened and also the time for etching away the porous Si substrate can be shortened, whereby substrate formation can be effected highly efficiently.

It is also possible to bond the thin film Si monocrystalline layer 1302 directly to the oxidized film 1305 without forming the oxidized film 1303 shown in Fig. 13, and it is also possible to bond an insulating substrate such as glass, etc. in place of the oxidized film 1305 formed on the Si substrate

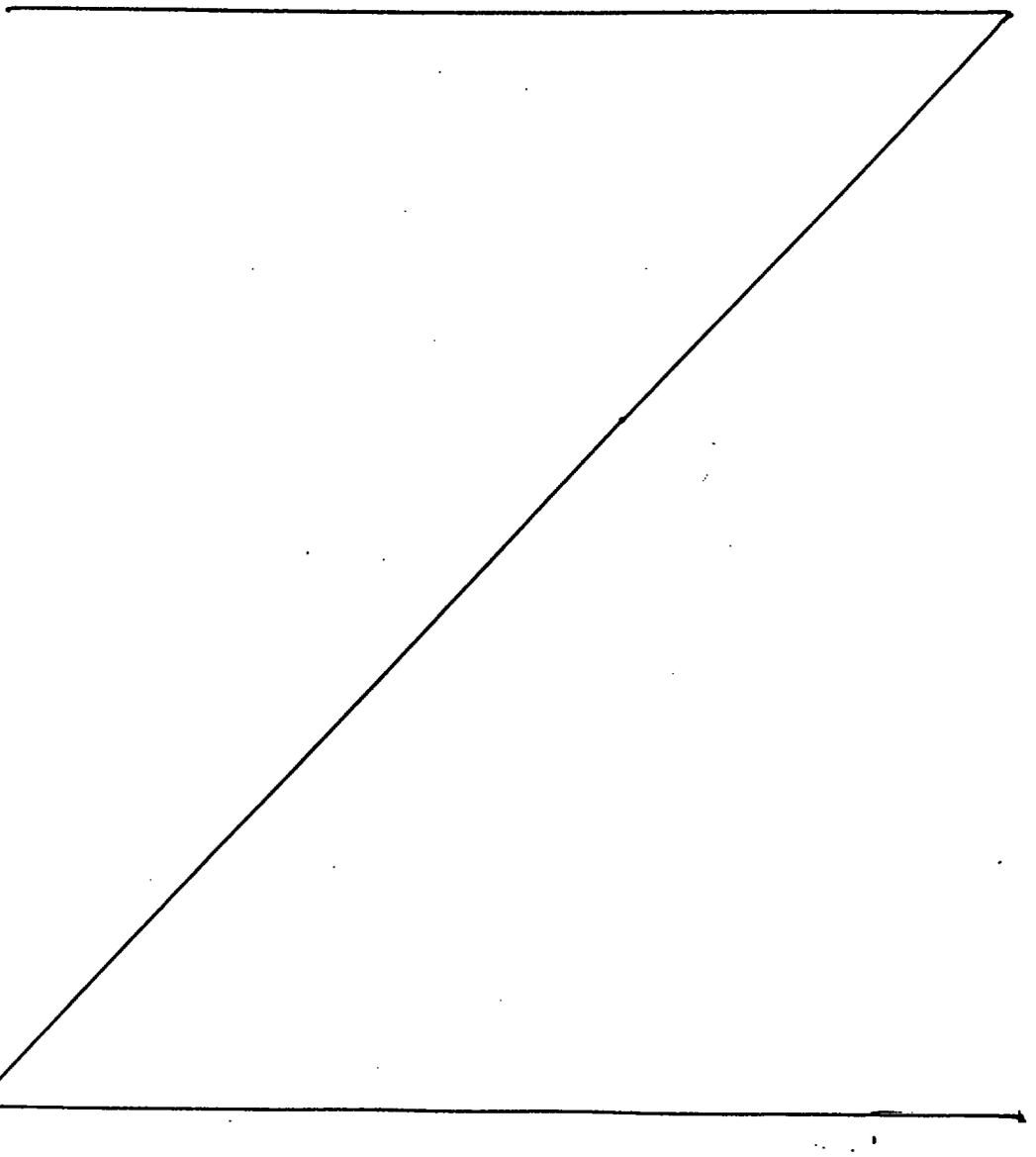
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1304.

Also, the respective steps in the Embodiments 1 to 12 can be also incorporated in the present Embodiment.

The semiconductor substrate thus obtained has the same excellent performances as those of the semiconductor substrate obtained in Embodiments 1 to 12.



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Example 1

A P-type (100) monocrystalline Si substrate (Si wafer) having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 21 was grown an Si epitaxial layer to a thickness of 0.5 microns by the MBE (Molecular Beam Epitaxy) method. The deposition conditions are as follows:

Temperature: 700 ^{o}C

Pressure: 1 x 10^{-9} Torr

Growth rate: 0.1 nm/sec.

Next, on the surface of the epitaxial layer 21 was superposed another Si substrate 23 with an oxidized layer of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 21 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8).

As described above, chemical etching rate of ordinary Si monocrystal relative to hydrofluoric acid-

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nitric acid-acetic acid solution is about a little lower than 1 micron per minute (hydrofluoric acid-nitric acid-acetic acid solution, 1:3:8), but the chemical etching rate of a porous layer is accelerated by about 100-fold thereof. That is, the Si substrate 21 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a monocrystalline Si layer 22 having a thickness of 0.5 μm could be formed on the SiO_2 layer 24.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. Specifically, the whole surface of the 3 inches wafer was scanned for the measurement. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life

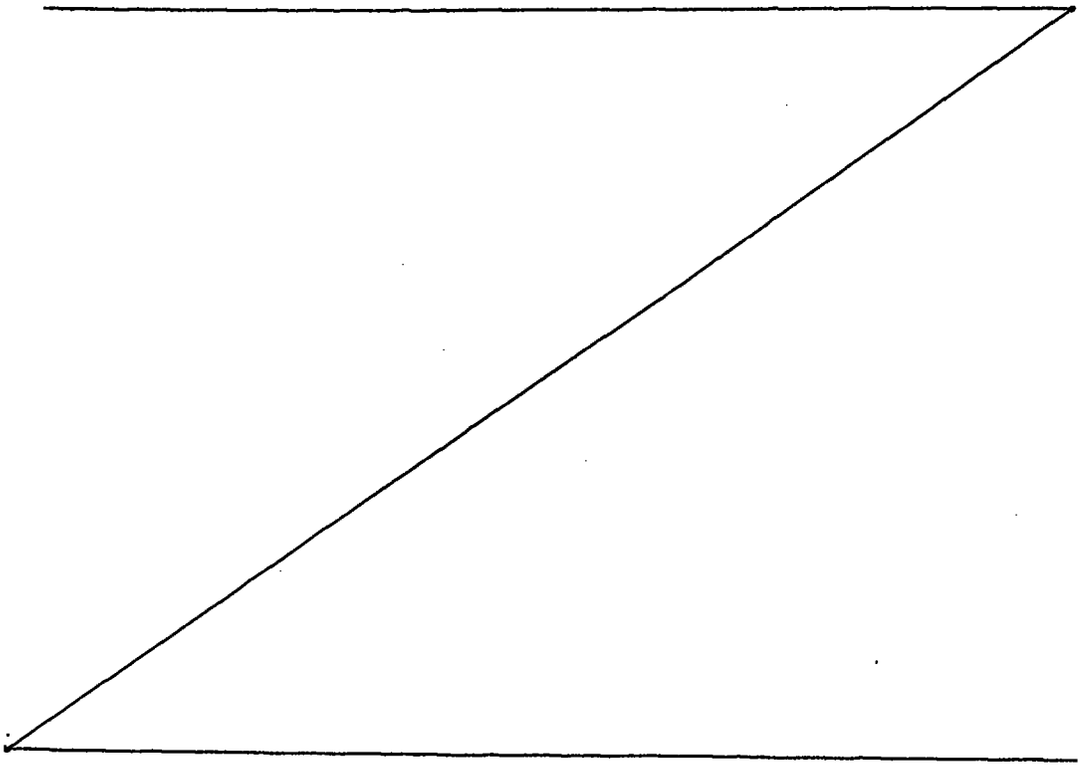
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time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0×10^{-3} sec. was exhibited.

Example 2

A P-type (100) monocrystalline Si substrate having a diameter of 4 inches and a thickness of 500 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 500 microns as a whole was made porous in 60 minutes.



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On the P-type (100) porous Si substrate 21 was grown at low temperature an Si epitaxial layer 22 to a thickness of 0.5 microns by the plasma CVD method. The deposition conditions are as follows:

Gas: SiH_4

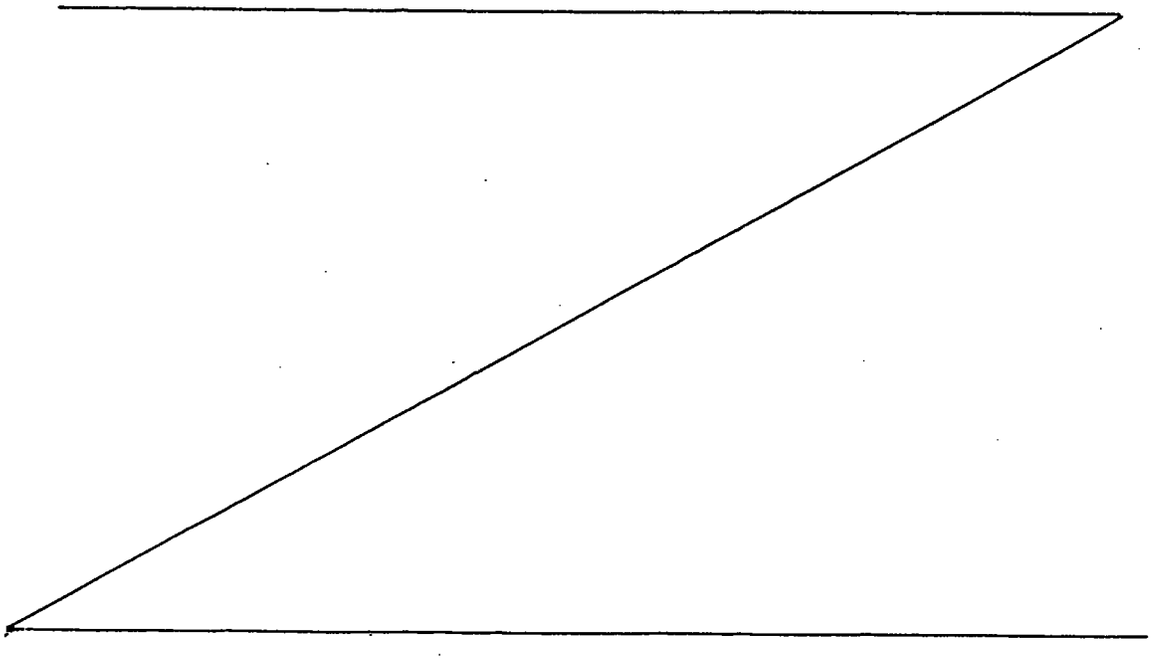
Radio frequency power: 100 W

Temperature: 800 ^{o}C

Pressure: 1 x 10^{-2} Torr

Growth rate: 2.5 nm/sec.

Next, on the surface of the epitaxial layer 22 was superposed another Si substrate 23 with an oxidized layer 24 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 700 ^{o}C for 0.5 hour, the two Si substrates were bonded



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firmly together. Then, the porous Si substrate 21 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8).

As described above, chemical etching rate of ordinary Si monocrystal relative to hydrofluoric acid-nitric acid-acetic acid solution is about a little lower than 1 micron per minute (hydrofluoric acid-nitric acid-acetic acid solution, 1:3:8), but the chemical etching rate of a porous layer is accelerated by about 100-fold thereof. That is, the Si substrate 21 made porous having a thickness of 500 microns was removed in 5 minutes.

Thus, a monocrystalline Si layer having a thickness of 0.5 μm could be formed on the SiO_2 layer 24.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. Specifically, the whole surface of the 4 inches wafer was scanned for the measurement. As the result, within the plane of the 4 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 7% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron

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microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0 x 10^{-3} sec. was exhibited.

Example 3

A P-type (100) monocrystalline Si substrate (Si wafer) having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 21 was grown an Si epitaxial layer 22 to a thickness of 0.5 microns by the bias-sputtering method. The deposition conditions are as follows:

RF frequency: 100 MHz

Radio frequency power: 600 W

Temperature: 300 ^oC

Ar gas pressure: 8 x 10^{-3} Torr

Growth time: 60 minutes

Target direct current bias: - 200 V

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Substrate direct current bias: + 5 V.

Next, on the surface of the epitaxial layer 22 was superposed another Si substrate 23 with an oxidized layer 24 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 21 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8).

As described above, chemical etching rate of ordinary Si monocrystal to hydrofluoric acid-nitric acid-acetic acid solution is about a little lower than 1 micron per minute (hydrofluoric acid-nitric acid-acetic acid solution, 1:3:8), the chemical etching rate of a porous layer is accelerated by about 100-fold thereof. That is, the Si substrate 21 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a monocrystalline Si layer having a thickness of 0.5 μm could be formed on the SiO_2 layer 24.

Example 4

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The

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porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 21 was grown an Si epitaxial layer 22 to a thickness of 0.5 microns by the liquid phase growth method. The growth conditions are as follows:

Solvent: Sn

Growth temperature: 900 ^{o}C

Growth atmosphere: H_2

Growth time: 10 minutes.

Next, on the surface of the epitaxial layer 22 was superposed another Si substrate 23 with an oxidized layer 24 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 21 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 21 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a monocrystalline Si layer 22 having a thickness of 0.5 μm could be formed on the SiO_2 layer 24.

<u>Example 5</u>

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A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 21 was grown an Si epitaxial layer 21 to a thickness of 0.5 microns by the low pressure CVD method. The deposition conditions are as follows:

Source gas: SiH_4

Carrier gas: H_2

Temperature: 850 ^oC

Pressure: 1 x 10^{-2} Torr

Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 22 was superposed another Si substrate with an oxidized layer 24 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^oC for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 21 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 21 made porous having a thickness of 200 microns was removed in 2 minutes.

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Thus, a monocrystalline Si layer having a thickness of 0.5 μm could be formed on the SiO_2 layer 24. When SiH_2Cl_2 was employed as the source gas, although it was necessary to elevate the growth temperture by some ten degrees, the accelerted etching characteristics inherent in the porous substrate were maintained.

Example 6

On a P-type (100) Si substrate 121 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 122 with a thickness of 1 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 2 min.

The substrate 121 was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 121 having a thickness of 200 microns as a whole was made porous in 24 minutes. In this anodization, only the P-type (100) Si substrate 121 was made porous, and there was no change in the Si epitaxial layer 122.

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Next, on the surface of the epitaxial layer 122 was superposed another Si substrate 124 with an oxidized layer 125 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 123 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 123 made porous having a thickness of 200 microns was removed in 2 minutes.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^{3}/cm^{2}$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the

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microwave reflection method, a high value of 2.0×10^{-3} sec. was exhibited.

Example 7

On a P-type (100) Si substrate having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 122 to a thickness of 0.5 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 121 having a thickness of 200 microns as a whole was made porous in 24 minutes. In this anodization, only the P-type (100) Si substrate was made porous, and there was no change in the Si epitaxial layer 122.

Next, on the surface of the epitaxial layer 122 was superposed another Si substrate 124 with an oxidized layer 125 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded

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firmly together. Then, the porous Si substrate 123 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 123 made porous having a thickness of 200 microns was removed in 2 minutes.

As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the Si layer 122 to maintain good crystallinity.

Example 8

On a surface of a P-type (100) Si substrate 121 having a diameter of 3 inches and a thickness of 200 microns was formed an N-type Si layer 122 to a thickness of 1 micron by ion implantation of protons into the surface. The amount of H^+ implanted was found to be 5×10^{15} (ions/cm^2). The substrate 121 was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 121 having a thickness of 200 microns as a whole was made porous in 24 minutes. As described above, in this anodization, only the P-type (100) Si substrate 121 was made porous, and there was no change in the N-type Si layer 122. Next, on the surface of the N-type Si layer 122

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was superposed another Si substrate 124 with an oxidized layer 125 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 123 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 123 made porous having a thickness of 200 microns was removed in 2 minutes.

As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the Si layer 122 to maintain good crystallinity.

Example 9

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 11 was grown an Si epitaxial layer 12 to a thickness of 0.5 microns by the MBE (Molecular Beam Epitaxy) method.

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The deposition conditions are as follows:

Temperature: 700 °C

Pressure: 1×10^{-9} Torr

Growth rate: 0.1 nm/sec.

Next, on the surface of the epitaxial layer 12 was superposed another Si substrate 13 with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 µm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 11 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 15, a substrate having a monocrystalline Si layer having a thickness of 0.5 µm on the SiO_2 layer 14 could be formed.

As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

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Example 10

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 11 was grown an Si epitaxial layer 12 to a thickness of 0.5 microns by the plasma CVD method. The deposition conditions are as follows:

Gas: SiH_4

Radio frequency power: 100 W

Temperature: 800 °C

Pressure: 1×10^{-2} Torr

Growth rate: 2.5 nm/sec.

Next, on the surface of the epitaxial layer 12 was superposed another Si substrate with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon

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nitride film on the porous substrate 11 was removed by reactive ion etching. Then, the porous Si substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 11 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 15, a substrate having a monocrystalline Si layer 12 having a thickness of 0.5 μm on the SiO_2 layer could be formed.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of observation by defect delineation etching by use of Sirtle etching, the dislocation defect density was found to be suppressed $1 \times 10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0×10^{-3} sec. was exhibited.

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Example 11

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 11 was grown an Si epitaxial layer 12 to a thickness of 0.5 microns by the bias sputtering method. The deposition conditions are as follows:

RF frequency: 100 MHz

Radio frequency power: 600 W

Temperature: 300 ^{o}C

Ar gas pressure: 8×10^{-3} Torr

Growth time: 60 min.

Target direct current bias: -200 V

Substrate direct current bias: + 5 V

Next, on the surface of the epitaxial layer 12 was superposed another Si substrate with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a

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thickness of 0.1 μm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 11 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 15, a substrate having a monocrystalline Si layer 12 having a thickness of 0.5 μm on the SiO_2 layer 14 could be formed.

Also, the same effect was obtained when Apiezon Wax was coated in place of the Si_3N_4 layer, and only the Si substrate made porous could be completely removed.

Example 12

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 11 was grown an Si epitaxial layer 12 to a thickness of 0.5 microns by the liquid phase growth method. The

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growth conditions are as follows:

Solvent: Sn

Growth temperature: 900 °C

Growth atmosphere: H_2

Growth time: 10 min.

Next, on the surface of the epitaxial layer 12 was superposed another Si substrate 13 with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 11 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 15, a substrate having a monocrystalline Si layer 12 having a thickness of 0.5 μm on the SiO_2 layer 14 could be formed.

Also, the same effect was obtained when Apiezon Wax was coated in place of the Si_3N_4 layer, and only the Si substrate made porous could be

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completely removed.

Example 13

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 11 was grown an Si epitaxial layer 12 to a thickness of 0.5 microns by the low pressure CVD method. The deposition conditions are as follows:

Source gas: SiH_4

Carrier gas: H_2

Temperature: 850 ^oC

Pressure: 1 x 10^{-2} Torr

Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 12 was superposed another Si substrate 13 with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^oC for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon

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nitride film 15 on the porous substrate 11 was removed by reactive ion etching. Then, the porous Si substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 11 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 15, a substrate having a monocrystalline Si layer having a thickness of 0.5 μm on the SiO_2 layer 14 could be formed.

When SiH_2Cl_2 was employed as the source gas, although it was required to elevate the growth temperature by some ten degrees, the accelerated chemical etching characteristics inherent in the porous substrate could be maintained.

Example 14

On a P-type (100) Si substrate 111 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 112 with a thickness of 1 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 2 min.

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The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 111 having a thickness of 200 microns as a whole was made porous in 24 minutes. In this anodization, only the P-type (100) Si substrate 111 was made porous, and there was no change in the Si epitaxial layer 112. Next, on the surface of the epitaxial layer 112 was superposed another Si substrate 114 with an oxidized layer of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1μm. Thereafter, only the nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 111 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 113 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 116, a substrate having a monocrystalline Si layer 112 having a thickness of 1 μm could be formed on SiO_2.

Also the thickness of the monocrystalline Si

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layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the microwave reflection method, a high value of 2.0 x 10^{-3} sec. was exhibited.

Example 15

On a P-type (100) Si substrate 111 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 112 to a thickness of 0.5 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

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Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 111 having a thickness of 200 microns as a whole was made porous in 24 minutes. In this anodization, only the P-type (100) Si substrate 111 was made porous, and there was no change in the Si epitaxial layer 112.

Next, on the surface of the epitaxial layer 112 was superposed an Si substrate 114 with an oxidized layer of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon nitride film 116 on the porous substrate 113 was removed by reactive ion etching. Then, the porous Si substrate 113 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 113 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 116, a substrate having a monocrystalline Si layer 112 having

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a thickness of 0.5 μm could be formed on the SiO_2 layer 115. As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 16

On a surface of a P-type (100) Si substrate 111 having a diameter of 3 inches and a thickness of 200 microns was formed an N-type Si layer 112 to a thickness of 1 micron by ion implantation of protons into the surface. The amount of H^+ implanted was found to be 5×10^{15} (ions/cm^2). The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 111 having a thickness of 200 microns as a whole was made porous in 24 minutes. In this anodization, only the P-type (100) Si substrate 111 was made porous, and there was no change in the N-type Si layer 112. Next, on the surface of the N-type Si layer 112 was superposed another Si substrate 114 with an oxidized layer 115 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the Si substrates were bonded firmly together. Subsequently, Si_3N_4 was coated on

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the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 113 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 113 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 116, a substrate having a monocrystalline Si layer 112 having a thickness of 1.0 μm could be formed on the SiO_2. As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 17

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 31 was

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grown an Si epitaxial layer 32 to a thickness of 0.5 microns by the MBE (Molecular Beam Epitaxy) method. The deposition conditions are as follows:

Temperature: 700 °C

Pressure: 1×10^{-9} Torr

Growth rate: 0.1 nm/sec.

Next, on the surface of the epitaxial layer 32 was formed an oxide layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate having an oxide layer 34 of 5000 angstroms formed on the surface was superposed the above oxide layer 36, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the both were bonded firmly together. Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 31 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 35, a substrate having a thin film monocrystalline Si layer 32 could be formed on the SiO_2. As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal

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defect had been introduced in the Si layer to maintain good crystallinity.

Example 18

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 31 was grown an Si epitaxial layer 32 to a thickness of 5 microns according to the plasma CVD method. The deposition conditions are as follows:

Gas: SiH_4

Radio frequency power: 100 W

Temperature: 800 ^oC

Pressure: 1 x 10^{-2} Torr

Growth rate: 2.5 nm/sec.

Next, on the surface of the epitaxial layer 32 was formed an oxide layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate 33 having an oxide layer 34 of 5000 angstroms formed on the surface was superposed the above oxide layer 36, and by heating in a nitrogen atmosphere at 800 ^oC for 0.5 hour, the both were bonded firmly together. Si_3N_4 was

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coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 31 was chemically etched away by use of a KOH solution (6 M). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer, a substrate having a monocrystalline Si layer 32 with good crystallinity could be formed on the SiO_2 layer.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the

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monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0×10^{-3} sec. was exhibited.

Example 19

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 31 was grown an Si epitaxial layer 32 to a thickness of 1 micron according to the bias sputtering method. The deposition conditions are as follows:

RF frequency: 100 MHz

Radio frequency power: 600 W

Temperature: 800 ^{o}C

Ar gas pressure: 8×10^{-3} Torr

Growth time: 120 min.

Target direct current bias: - 200 V

Substrate direct curren bias: + 5V

Next, on the surface of the epitaxial layer 32 was formed an oxide layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate 33 having an oxide layer 34 of 5000 angstroms formed on the surface was superposed the above oxide layer 36, and by

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heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the both were bonded firmly together. Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the nitride film on the porous substrate 31 was removed by reactive ion etching. Then, the porous Si substrate 31 was chemically etched away by use of a hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer, a substrate having a monocrystalline Si layer 32 with good crystallinity could be formed on the SiO_2 layer.

The same effect was obtained also when Apiezon Wax was coated in place of the Si_3N_4 layer 35, whereby only the Si substrate 35 made porous could be completely removed.

Example 20

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate

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31 was grown an Si epitaxial layer 32 to a thickness of 5 micron by the liquid phase growth method. The growth conditions are as follows:

Solvent: Sn

Growth temperature: 900 ^{o}C

Growth atmosphere: H_2

Growth time: 10 min.

Next, on the surface of the epitaxial layer 32 was formed an oxide layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate 33 having an oxide layer 34 of 5000 angstroms formed on the surface was superposed the above oxide layer 36, and by heating in a nitrogen atmosphere at 700 ^{o}C for 0.5 hour, the both were bonded firmly together. Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 31 was chemically etched away by use of a hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 35, a substrate having a monocrystalline Si layer 32 could be formed on the SiO_2. The same effect was obtained also when Apiezon Wax was coated in place of the Si_3N_4 layer.

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whereby only the Si substrate made porous could be completely removed.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0 x 10^{-3} sec. was exhibited.

Example 21

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a

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thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 31 was grown an Si epitaxial layer 32 to a thickness of 1.0 micron at low temperature by the low pressure CVD method. The deposition conditions are as follows:

Source gas: SiH_4

Carrier gas: H_2

Temperature: 850 ^oC

Pressure: 1 x 10^{-2} Torr

Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 32 was formed an oxidized layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate 33 having an oxide layer 34 of 5000 angstroms formed on the surface was superposed the above oxide layer 36, and by heating in a nitrogen atmosphere at 700 ^oC for 0.5 hour, the both were bonded firmly together. Si_3N_4 was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 μm. Thereafter, only the silicon nitride film 35 on the porous substrate 31 was removed by reactive ion etching. Then, the porous Si substrate 31 was chemically etched away by use of a hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 35, a

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substrate having a monocrystalline Si layer 32 could be formed on the SiO_2 layer.

When SiH_2Cl_2 was employed as the source gas, although the growth temperature was required to be elevated by some ten degrees, the accelerated chemical etching characteristics inherent in the porous substrate could be maintained.

Example 22

On a P-type (100) Si substrate 131 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 132 with a thickness of 1 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM
H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 2 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 131 having a thickness of 200 microns as a whole was made porous in 24 minutes. As described above, only the P-type (100) Si substrate 131 was made porous in this anodization, and there was no change in the Si

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epitaxial layer 132. Next, on the surface of the epitaxial layer 132 was formed an oxidized layer 137, another Si substrate 134 having an oxidized layer 135 of 5000 angstroms formed on the surface was superposed on the above oxidized layer 137, and the two Si substrates were bonded together firmly by heating at 800 ^{o}C for 0.5 hour in a nitrogen atmosphere. By the low pressure CVD method, Si_3N_4 was coated with a thickness of 0.1 μm on the bonded substrate. Then only the silicon nitride film on the porous substrate was removed by reactive ion etching. Subsequently, the porous Si substrate 133 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 133 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 136, a substrate having the monocrystalline Si layer 132 having a thickness of 1 μm could be formed on SiO_2.

As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 23

On a P-type (100) Si substrate 131 having a diameter of 4 inches and a thickness of 500 microns

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was grown an Si epitaxial layer 132 with a thickness of 0.5 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 131 having a thickness of 500 microns as a whole was made porous. Only the P-type (100) Si substrate 131 was made porous in this anodization, and there was no change in the Si epitaxial layer 132.

Next, on the surface of the epitaxial layer 132 was formed an oxidized layer 137 with a thickness of 1000 angstroms. Then, another Si substrate 134 having an oxidized layer 135 of 5000 angstroms formed on the surface was adhered on the above oxidized layer 137, and the both were bonded together firmly by heating at 700 °C for 0.5 hour in a nitrogen atmosphere. By the low pressure CVD method, Si_3N_4 was coated with a thickness of 0.1 μm on the bonded substrate, and only the silicon nitride film 136 on

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the porous substrate 133 was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate made porous having a thickness of 500 microns was removed in 5 minutes. After removal of the Si_3N_4 layer 136, a substrate having the monocrystalline Si layer 132 could be formed on SiO_2.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 4 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 8% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.1 x 10^{-3} sec. was exhibited.

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Example 24

On the surface of a P-type (100) Si substrate 131 having a diameter of 3 inches and a thickness of 200 microns was formed N-type Si layer 132 with a thickness of 1 micron by ion implantation of protons. The amount of H^+ implanted was 5×10^{15} (ions/cm^2). The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 131 having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si substrate 131 was made porous in this anodization, and there was no change in the N-type Si layer 132. Next, on the surface of the epitaxial layer 132 was formed an oxidized layer 137 with a thickness of 1000 angstroms. Then, another Si substrate 134 having an oxidized layer 135 of 5000 angstroms formed on the surface was adhered on the above oxidized layer 137, and the two Si substrates were bonded together firmly by heating at 700 °C for 0.5 hour. By the low pressure CVD method, Si_3N_4 was coated with a thickness of 0.1 μm on the bonded substrate. Then, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Subsequently, the porous Si substrate 133 was chemically etched away by use of hydrofluoric

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acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 136, a substrate having the monocrystalline Si layer 132 could be formed on SiO_2. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystalline defect had been introduced in the Si layer to maintain good crystallinity.

Example 25

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 41 was grown an Si epitaxial layer 42 to a thickness of 0.5 microns by the MBE (Molecular Beam Epitaxy) method. The deposition conditions are as follows:

Temperature: 700 ^oC

Pressure: 1×10^{-9} Torr

Growth rate: 0.1 nm/sec.

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Next, on the surface of the epitaxial layer 42 was formed an oxidized layer 45 with a thickness of 1000 angstroms. Then, another Si substrate 43 with an oxidized layer 44 of 5000 angstroms formed on the surface was superposed on the above oxidized layer 45, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 41 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 41 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a substrate having a thin film monocrystalline Si layer 42 could be formed on the SiO_2. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 26

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in

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24 minutes. On the P-type (100) porous Si substrate 41 was grown an Si epitaxial layer 42 to a thickness of 5 microns by the plasma CVD method. The deposition conditions are as follows:

Gas: SiH_4

Radio frequency power: 100 W

Temperature: 800 ^{o}C

Pressure: 1 x 10^{-2} Torr

Growth rate: 2.5 nm/sec.

Next, on the surface of the epitaxial layer 42 was formed an oxidized layer 45 with a thickness of 1000 angstroms. Then, another Si substrate 43 with an oxidized layer 44 of 5000 angstroms formed on the surface was superposed on the above oxidized layer 45, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 41 was chemically etched away by use of a KOH solution of 6 M.

As described above, ordinary chemical etching rate of Si monocrystal relative to 6M KOH solution is about a little lower than 1 micron per minute, but the chemical etching rate of a porous layer is accelerated by about 100-fold thereof. Then, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes.

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Thus, a monocrystalline Si layer having good crystallinity could be formed on the SiO_2.

Example 27

A P-type (100) monocrystalline Si substrate having a diameter of 5 inches and a thickness of 600 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 600 microns as a whole was made porous in 70 minutes. On the P-type (100) porous Si substrate 41 was grown an Si epitaxial layer 42 to a thickness of 1 micron by the bias-sputtering method. The deposition conditions are as follows:

RF frequency: 100 MHz

Radio frequency power: 600 w

Temperature: 300 ^{o}C

Ar gas pressure: 8 x 10^{-3} Torr

Growth time: 120 minutes

Target direct current bias: - 200 V

Substrate direct current bias: + 5 V.

Next, on the surface of the epitaxial layer 42 was formed an oxidized layer 45 with a thickness of 1000 angstroms. Then, another Si substrate 43 with an oxidized layer 44 of 5000 angstroms formed on the surface was superposed on the above oxidized layer 45,

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and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 41 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 41 made porous having a thickness of 600 microns was removed in 7 minutes.

Thus, a substrate having a monocrystalline Si layer 42 with good crystallinity could be formed on the SiO_2.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 5 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 8% or less based on the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method,

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a high value of 2.1×10^{-3} sec. was exhibited.

Example 28

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 41 was grown an Si epitaxial layer 42 to a thickness of 5 microns by the liquid phase growth method. The growth conditions are as follows:

Solvent: Sn

Growth temperature: 900 °C

Growth atmosphere: H_2

Growth time: 10 minutes.

Next, on the surface of the epitaxial layer 42 was formed an oxidized layer 45 with a thickness of 1000 angstroms. Then, another Si substrate 43 having an oxidized layer 44 of 5000 angstroms formed on the surface was closely contacted, and by heating in a nitrogen atmosphere at 700 °C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous Si substrate 41 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid

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solution (1:3:8). As the result, the Si substrate 41 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a substrate having a monocrystalline Si layer could be formed on the SiO_2.

Example 29

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 41 was grown an Si epitaxial layer 42 to a thickness of 1.0 microns by to the low pressure CVD method. The deposition conditions are as follows:

Source gas: SiH_4

Carrier gas: H_2

Temperature: 850 ^oC

Pressure: 1 x 10^{-2} Torr

Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 42 was formed an oxidized layer 45 with a thickness of 1000 angstroms. Then, another Si substrate 43 having an oxidized layer 44 of 5000 angstroms on the surface

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was closely contacted, and by heating in a nitrogen atmosphere at 700 °C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, the porous Si substrate 41 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 41 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a substrate having a monocrystalline Si layer 42 on SiO_2 could be formed. When SiH_2Cl_2 was employed, although it was necessary to elevate the growth temperature by some ten degrees, the accelerated chemical etching characteristics inherent in the porous substrate were maintained.

Example 30

On a P-type (100) Si substrate 141 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 142 with a thickness of 1 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 2 min.

The substrate was anodized in a 50% HF

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solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous. Only the P-type (100) Si substrate 141 was made porous in this anodization, and there was no change in the Si epitaxial layer 142. Next, on the surface of the epitaxial layer 142 was superposed another Si substrate 144 having an oxidized layer 145 of 5000 angstroms formed on the surface , and the two Si substrates were bonded together firmly by heating at 800 ^{o}C for 0.5 hour in a nitrogen atmosphere. Subsequently, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a substrate having a monocrystalline layer 142 with a thickness of 1 μm on SiO_2 could be formed. As the result of cross-sectional observation by a transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 31

On a P-type (100) Si substrate 141 having a

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diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 142 with a thickness of 0.5 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 ^oC

Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 141 having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si substrate 141 was made porous in this anodization, and there was no change in the Si epitaxial layer 142.

Next, on the surface of the epitaxial layer 142 was formed an oxidized layer 146 with a thickness of 1000 angstroms. Then, another Si substrate having an oxidized layer 145 of 5000 angstroms formed on the surface was closely contacted, and the two Si substrates were bonded together firmly by heating at 700 ^oC for 0.5 hour. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the

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result, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a substrate having a monocrystalline Si layer on SiO_2 could be formed. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 32

On the surface of a P-type (100) Si substrate 141 having a diameter of 3 inches and a thickness of 200 microns was formed an N-type Si layer 142 with a thickness of 1 micron by ion implantation of protons. The amount of H^+ implanted was 5×10^{15} (ions/cm^2). The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si substrate 141 was made porous in this anodization, and there was no change in the N-type Si layer 142. Next, on the surface of the epitaxial layer 142 was formed an oxidized layer 146 with a thickness of 1000 angstroms. Then, another Si substrate having an oxidized layer 145 of 5000 angstroms formed on the surface was

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closely contacted with the above oxidized layer 146, and the two Si substrates were bonded together firmly by heating at 700 ^{o}C for 0.5 hour. Subsequently, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes.

A substrate having a monocrystalline Si layer on SiO_2 could be formed.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less based on the maximum value of the thickness. As the result of plan-view observation of the monocrystalline Si layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline layer by use of the MOS C-t method, a

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high value of 2.2×10^{-3} sec. was exhibited.

Example 33

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 51 was grown an Si epitaxial layer 52 to a thickness of 0.5 microns at a low temperature by the MBE method. The deposition conditions are as follows:

Temperature: 700 °C

Pressure: 1×10^{-9} Torr

Growth rate: 0.1 nm/sec.

Next, on the surface of the epitaxial layer 52 was superposed a fused silica substrate applied with optical polishing, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two substrates were bonded firmly together. By the low pressure CVD method, Si_3N_4 was coated on the bonded substrate with a thickness of 0.1 μm. Subsequently, only the nitride film 54 on the porous substrate 51 was removed by reactive ion etching. Then, the porous Si

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substrate 51 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 51 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 54, a substrate having the monocrystalline Si layer 52 with a thickness of 0.5 μm on the fused silica 53 could be obtained.

As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 34

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 51 was grown an Si epitaxial layer 52 to a thickness of 5 microns by the plasma CVD method. The deposition conditions are as follows:

Gas: SiH_4

Radio frequency power: 100 W

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Temperature: 800 °C

Pressure: 1 x 10^{-2} Torr

Growth rate: 2.5 nm/sec.

Next, on the surface of the epitaxial layer 52 was superposed a glass substrate having a softening point around 500 °C applied with optical polishing, and by heating in a nitrogen atmosphere at 450 °C for 0.5 hour, the two substrates were bonded firmly together. By the low pressure CVD method, Si_3N_4 was coated on the bonded substrate with a thickness of 0.1 µm. Subsequently, only the nitride film 54 on the porous substrate 51 was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of 6M KOH solution. As the result, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer, the monocrystalline layer 52 with a thickness of 5 µm on the low softening glass substrate 53 could be obtained.

Example 35

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 µm/min. and the P-type (100) Si substrate having a

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thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 51 was grown an Si epitaxial layer to a thickness of 1.0 micron by the bias-sputtering method. The deposition conditions are as follows:

RF frequency: 100 MHz

Radio frequency power: 600 W

Temperature: 300 ^{o}C

Ar gas pressure: 8 x 10^{-3} Torr

Growth time: 120 minutes

Target direct current bias: - 200 V

Substrate direct current bias: + 5 V.

Next, on the surface of the epitaxial layer 52 was superposed a glass substrate 53 having a softening point around 500 ^{o}C applied with optical polishing, and by heating in a nitrogen atmosphere at 450 ^{o}C for 0.5 hour, the two substrate were bonded firmly together. By the low pressure CVD method, Si_3N_4 was coated on the bonded substrate with a thickness of 0.1 µm. Subsequently, only the nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 51 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4

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layer 54, a substrate having the monocrystalline layer 52 with a thickness of 1.0 μm on the low melting point glass could be obtained. The same effect could be also obtained when Apiezon Wax was coated in place of the Si_3N_4 layer, and only the Si substrate 51 made porous could be removed.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less based on the maximum value of the thickness. As the result of plan-view observation of the monocrystalline Si layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0 x 10^{-3} sec. was exhibited.

Example 36

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200

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microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 51 was grown an Si epitaxial layer to a thickness of 10 microns by the liquid phase growth method. The growth conditions are as follows:

Solvent: Sn

Growth temperature: 900 °C

Growth atmosphere: H_2

Growth time: 20 minutes.

Next, on the surface of the epitaxial layer 52 was superposed a glass substrate 53 having a softening point around 800 °C applied with optical polishing, and by heating in a nitrogen atmosphere at 750 °C for 0.5 hour, the two substrates were bonded firmly together. By the low pressure CVD method, Si_3N_4 was coated on the bonded substrate with a thickness of 0.1 μm. Subsequently, only the nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 51 made porous having a thickness of 200 microns was

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removed in 2 minutes. After removal of the Si_3N_4 layer 54, a substrate having the monocrystalline Si layer 52 with a thickness of 10 µm on the glass 53 could be obtained. The same effect could be also obtained when Apiezon Wax was coated in place of the Si_3N_4 layer, and only the Si substrate made porous could be completely removed.

Example 37

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 µm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 51 was grown an Si epitaxial layer 52 to a thickness of 1.0 micron by the low pressure CVD method. The deposition conditions are as follows:

Source gas: SiH_4 800 SCCM

Carrier gas: H_2 150 l/min.

Temperature: 850 ^oC

Pressure: 1 x 10^{-2} Torr

Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 52 was superposed a fused silica substrate 53 applied

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with optical polishing, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together.

By the low pressure CVD method, Si_3N_4 was coated on the bonded substrate with a thickness of 0.1 μm. Subsequently, only the nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 51 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution. As the result, the Si substrate 51 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer, a substrate having the monocrystalline Si layer 52 with a thickness of 1.0 μm on the fused silica substrate 53 could be formed.

When SiH_2Cl_2 as the source gas was employed, although it was necessary to elevate the growth temperature by some ten degrees, the accelerated chemical etching characteristics inherent in the porous substrate were maintained.

Example 38

On a P-type (100) Si substrate 151 having a diameter of 4 inches and a thickness of 300 microns was grown an Si epitaxial layer 152 with a thickness of 1 micron by the CVD method. The deposition conditions are as follows:

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Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 2 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 151 having a thickness of 300 microns as a whole was made porous in 36 minutes. As described above, only the P-type (100) Si substrate 151 was made porous in this anodization, and there was no change in the Si epitaxial layer 152. Next, on the surface of the epitaxial layer 152 was superposed a fused silica substrate 154 applied with optical polishing, and the two substrate were bonded together firmly by heating at 800 °C for 0.5 hour in a nitrogen atmosphere. By the low pressure CVD method, Si_3N_4 was deposited with a thickness of 0.1 μm to be coated on the bonded substrate. Subsequently the nitride film 155 on the porous substrate 153 was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 153 made porous having a thickness of 300

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microns was removed in 4 minutes. After removal of the Si_3N_4 layer 155, a substrate having the monocrystalline Si layer 152 having a thickness of 1 μm on the fused silica substrate 154 could be formed.

As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 39

On a P-type (100) Si substrate 151 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 152 with a thickness of 0.5 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 151 having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si substrate was made porous in this anodization, and

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there was no change in the Si epitaxial layer 152.

Next, on the surface of the epitaxial layer 152 was superposed a fused silica substrate 154 applied with optical polishing, and the two substrates were bonded together firmly by heating at 800 ^{o}C for 0.5 hour. By the low pressure CVD method, Si_3N_4 was deposited with a thickness of 0.1 μm to be coated on the bonded substrate. Subsequently the nitride film 155 on the porous substrate 153 was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 153 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si_3N_4 layer 155, a substrate having the monocrystalline Si layer 152 having a thickness of 0.5 μm on the fused silica 154 could be formed. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 40

On the surface of a P-type (100) Si substrate 151 having a diameter of 4 inches and a thickness of 300 microns was formed an N-type Si layer 152 with a thickness of 1 micron by ion implantation of protons.

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The amount of H+ implanted was 5 x 1015 (ions/cm^2). The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 151 having a thickness of 300 microns as a whole was made porous in 37 minutes. Only the P-type (100) Si substrate was made porous in this anodization, and there was no change in the N-type Si layer 152. Next, on the surface of the N-type Si layer 152 was superposed a fused silica substrate 154 with optical polishing, and the two substrates were bonded together firmly by heating at 800 ^{o}C for 0.5 hour in a nitrogen atmosphere. By the low pressure CVD method, Si_3N_4 was deposited to a thickness of 0.1 μm to be coated on the bonded substrate. Subsequently, only the nitride film 155 on the porous substate 153 was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution. As the result, the Si substrate 151 made porous having a thickness of 300 microns was removed in 4 minutes. After removal of the Si_3N_4 layer 155, a substrate having the monocrystalline Si layer 152 with a thickness of 1.0 μm on the fused silica 154 could be formed.

Also the thickness of the monocrystalline Si

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layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 4 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 6% or less based on the maximum value of the thickness. As the result of plan-view observation of the monocrystalline Si layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed $1 \times 10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.2×10^{-3} sec. was exhibited.

Shortly speaking, according to the present invention, in obtaining an Si crystalline layer excellent in crystallinity equal to monocrystalline Si wafer also on a light-transparent insulating material substrate represented by glass, a process for forming a semiconductor substrate excellent in aspects of productivity, uniformity, controllability, economy can be provided. Further, according to the present invention, there can be provided a process for forming a semiconductor substrate broad in scope of

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application which can make avail of the advantages of the SOI device of the prior.

Example 41

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 61 was grown an Si epitaxial layer 62 to a thickness of 0.5 microns by the MBE method. The deposition conditions are as follows:

Temperature: 700 ^{o}C

Pressure: 1 x 10^{-9} Torr

Growth rate: 0.1 nm/sec.

Next, on the surface of the epitaxial layer 62 was superposed a fused silica substrate 63 applied with optical polishing, and by heating in a nitrogen atmosphere at 800 ^{o}C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous Si substrate 61 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution. As the result, the Si substrate 61 made porous having

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a thickness of 200 microns was removed in 2 minutes. A substrate having the monocrystalline Si layer 62 with a thickness of 0.5 μm on the fused silica 63 could be obtained. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

Example 42

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 61 was grown an Si epitaxial layer 62 to a thickness of 5 microns by the plasma CVD method. The deposition conditions are as follows:

Gas: SiH_4

Radio frequency power: 100 W

Temperature: 800 ^oC

Pressure: 1 x 10^{-2} Torr

Growth rate: 2.5 nm/sec.

Next, on the surface of the epitaxial layer 62

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was superposed a glass substrate having a softening point around 500 °C applied with optical polishing, and by heating in a nitrogen atmosphere at 450 °C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous Si substrate 61 was chemically etched away by use of 6M KOH solution. As the result, the Si substrate 61 made porous having a thickness of 200 microns was removed in 2 minutes. A substrate having the monocrystalline Si layer 62 with a thickness of 5 μm on the low softening point glass 63 could be obtained.

Example 43

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 61 was grown an Si epitaxial layer 62 to a thickness of 1.0 micron by the bias-sputtering method. The deposition conditions are as follows:

RF frequency: 100 MHz

Radio frequency power: 600 W

Temperature: 300 °C

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Ar gas pressure: 8×10^{-3} Torr

Growth time: 120 minutes

Target direct current bias: - 200 V

Substrate direct current bias: + 5 V.

Next, on the surface of the epitaxial layer 62 was superposed a glass substrate 63 having a softening point around 500 °C applied with optical polishing, and by heating in a nitrogen atmosphere at 450 °C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous Si substrate 61 was chemically etched away by use of 7 M NaOH solution.

As described above, the chemical etching rate of ordinary Si monocrystal relative to 7 M NaOH solution is about a little less than 1 micron per minute, but the chemical etching rate of the porous layer is accelerated by about 100-fold thereof. That is, the Si substrate 61 made porous having a thickness of 200 microns was removed in 2 minutes. A substrate having the monocrystalline Si layer 62 with a thickness of 1.0 μm on the low melting point glass 63 could be formed.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the

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monocrystalline Si layer was found to be suppressed 5% or less based on the maximum value of the thickness. As the result of plan-view observation of the monocrystalline Si layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline layer by use of the MOS C-t method, a high value of 2.1 x 10^{-3} sec. was exhibited.

Example 44

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 61 was grown an Si epitaxial layer 62 to a thickness of 10 microns by the liquid phase growth method. The growth conditions are as follows:

Solvent: Sn

Growth temperature: 900 ^oC

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Growth atmosphere: H_2

Growth time: 20 minutes.

Next, on the surface of the epitaxial layer 62 was superposed a glass substrate 63 having a softening point around 800 °C applied with optical polishing, and by heating in a nitrogen atmosphere at 750 °C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous Si substrate 61 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution. As the result, the Si substrate 61 made porous having a thickness of 200 microns was removed in 2 minutes. A substrate having the monocrystalline Si layer 62 with a thickness of 10 µm on the glass 63 could be obtained.

Example 45

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 µm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 61 was grown an Si epitaxial layer to a thickness of 1.0 micron by the low pressure CVD method. The deposition conditions are as follows:

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Source gas: SiH_4 800 SCCM

Carrier gas: H_2 150 l/min.

Temperature: 850 °C

Pressure: 1×10^{-2} Torr

Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 62 was superposed a fused silica substrate 63 applied with optical polishing, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous Si substrate 61 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution. As the result, the Si substrate 61 made porous having a thickness of 200 microns was removed in 2 minutes. A substrate having the monocrystalline Si layer 62 with a thickness of 1.0 μm on the fused silica 63 could be formed. When SiH_2Cl_2 as the source gas was employed, although it was necessary to elevate the growth temperature by some ten degrees, the accelerated chemical etching characteristics inherent in the porous substrate were maintained.

Example 46

On a P-type (100) Si substrate 161 having a diameter of 4 inches and a thickness of 300 microns was grown an Si epitaxial layer 162 with a thickness of 1 micron by the CVD method. The deposition

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conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 2 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 161 having a thickness of 300 microns as a whole was made porous in 37 minutes. Only the P-type (100) Si substrate 161 was made porous in this anodization, and there was no change in the Si epitaxial layer 162. Next, on the surface of the epitaxial layer was superposed an optical polished fused silica glass substrate 164 and the two substrates were bonded together firmly by heating at 800 °C for 0.5 hour in a nitrogen atmosphere. Then, the porous Si substrate 163 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 163 made porous having a thickness of 300 microns was removed in 4 minutes. A substrate having the monocrystalline Si layer 162 having a thickness of 1 μm on the fused silica glass substrate 164 could be formed.

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Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 4 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 7% or less based on the maximum value of the thickness. As the result of plan-view observation of the monocrystalline Si layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0 x 10^{-3} sec. was exhibited.

Example 47

On a P-type (100) Si substrate 161 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 162 with a thickness of 0.5 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

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Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 161 having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si substrate 161 was made porous in this anodization, and there was no change in the Si epitaxial layer 162.

Next, on the surface of the epitaxial layer 162 was superposed an optical polished fused silica glass substrate 164 and the two substrates were bonded together firmly by heating at 800 ^{o}C for 0.5 hour. Then, the porous Si substrate 163 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution. As the result, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes. A monocrystalline Si layer having a thickness of 0.5 μm on the glass substrate could be formed. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystalline defect had been introduced in the Si layer to maintain good crystallinity.

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On the surface of a P-type (100) Si substrate 161 having a diameter of 3 inches and a thickness of 200 microns was formed an N-type Si layer 162 with a thickness of 1 micron by ion implantation of protons. The amount of H^+ implanted was 5×10^{15} (ions/cm^2). The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm^2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 161 having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si substrate 161 was made porous in this anodization, and there was no change in the N-type Si layer 162. Next, on the surface of the epitaxial layer 162 was superposed an optical polished fused silica glass substrate 164 and the two substrates were bonded together firmly by heating at 800 °C for 0.5 hour. Then, the porous Si substrate 163 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 163 made porous having a thickness of 200 microns was removed in 4 minutes. A monocrystalline Si layer 162 with a thickness of 1.0 μm on the glass substrate 164 could be formed. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been

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introduced in the Si layer to maintain good crystallinity.

Example 49

A P-type (100) monocrystalline Si substrate having a diameter of 6 inches and a thickness of 600 microns was anodized in a 50 % HF solution. The current density at this time was 10 mA/cm^2. In 10 minutes, a porous layer having a thickness of 20 microns was formed on the surface. On the P-type (100) porous Si substrate was grown an Si epitaxial layer to a thickness of 0.5 micron by the low pressure CVD method. The deposition conditions are as follows:

Gas: SiH_2Cl_2 (0.6 l/min), H_2 (100 l/min.)

Temperature: 850 ^oC

Pressure: 50 Torr

Growth rate: 0.1 μm/min.

Next, the surface of the epitaxial layer was thermally oxidized to 50 nm. On the thus obtained thermally oxidized film was superposed another silicon substrate having an oxidized layer of 0.8 micron on the surface, and by heating in a nitrogen atmosphere at 900 ^oC for 1.5 hours, the two substrates were firmly bonded together.

Thereafter, grinding of 585 microns was applied from the back side of the silicon substrate to have the porous layer exposed.

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By the plasma CVD method, Si_3N_4 was deposited to a thickness of 0.1 μm to be coated on the bonded substrate. Subsequently, only the silicon nitride film on the porous substrate was removed by reactive ion etching.

Then, the bonded substrate was subjected to chemically selective etching by use of a hydrofluoric acid-nitric acid-acetic acid solution. After 15 minutes, the porous Si layer was chemically selectively etched to be completely removed, and only the monocrystalline Si layer as the etch-stop material remained without being chemically etched.

The chemical etching rate of non-porous Si monocrystalline relative to the etchant is very low as about 40 angstroms even after 15 minutes, whereby the selective ratio of the etching rate between the non-porous layer and the porous layer is very large and the etched amount in the non-porous Si layer was practically negligible. After removal of the Si_3N_4 layer, a monocrystalline Si layer having a thickness of 0.5 μm on the silicon substrate having an insulating layer on the surface could be formed.

The same effect was also obtained, when Apiezon Wax or Electron Wax was coated in place of the Si_3N_4, and only the Si layer made porous could be completely removed.

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Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 6 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 10% or less based on the maximum value of the thickness. As the result of plan view observation of the monocrystalline layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x $10^3/cm^2$ or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0 x 10^{-3} sec. was exhibited.

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WHAT IS CLAIMED IS:

1. A process for preparing a semiconductor member comprising the steps of:

forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of said non-porous monocrystalline semiconductor region, and then

removing said porous monocrystalline semiconductor region by etching.

2. A process for preparing a semiconductor member according to Claim 1, wherein said monocrystalline semiconductor comprises silicon.

3. A process for preparing a semiconductor member according to Claim 1, wherein said porous monocrystalline semiconductor region is P-type.

4. A process for preparing a semiconductor member according to Claim 1, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

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5. A process for preparing a semiconductor member according to Claim 1, wherein said bonding step is carried out in an atmosphere containing nitrogen.

6. A process for preparing a semiconductor member according to Claim 1, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

7. A process for preparing a semiconductor member according to Claim 1, wherein said non-porous monocrystalline semiconductor region is formed by epitaxial growth.

8. A process for preparing a semiconductor member according to Claim 1, wherein said non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

9. A process for preparing a semiconductor member according to Claim 1, wherein said porous monocrystalline semiconductor region is obtained by making the non-porous semiconductor monocrystalline

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region porous by anodization.

10. A process for preparing a semiconductor member according to Claim 9, wherein said anodization is carried out in an HF solution.

11. A process for preparing a semiconductor member according to Claim 2, wherein said non-porous monocrystalline semiconductor region is intrinsic or N-type.

12. A process for preparing a semiconductor member according to Claim 11, wherein said N-type silicon is formed by proton irradiation or epitaxial growth.

13. A process for preparing a semiconductor member according to Claim 1, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

14. A process for preparing a semiconductor member according to Claim 1, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

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15. A process for preparing a semiconductor member according to Claim 1, wherein etching of said porous monocrystalline semiconductor region is carried out under the state where the members bonded to each other are covered with an anti-etching material.

16. A process for preparing a semiconductor member according to Claim 15, wherein said anti-etching material is silicon nitride.

17. A process for preparing a semiconductor member according to Claim 15, wherein said anti-etching material is Apiezon Wax.

18. A process for preparing a semiconductor member comprising the steps of:

forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on the non-porous monocrystalline semiconductor side of said member, then

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of said insulating substance, and

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removing said porous monocrystalline semiconductor region by etching.

19. A process for preparing a semiconductor member according to Claim 18, wherein said monocrystalline semiconductor comprises silicon.

20. A process for preparing a semiconductor member according to Claim 18, wherein said porous monocrystalline semiconductor region is P-type.

21. A process for preparing a semiconductor member according to Claim 18, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

22. A process for preparing a semiconductor member according to Claim 18, wherein said bonding step is carried out in an atmosphere containing nitrogen.

23. A process for preparing a semiconductor member according to Claim 18, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

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24. A process for preparing a semiconductor member according to Claim 18, wherein said non-porous monocrystalline semiconductor region is formed by epitaxial growth.

25. A process for preparing a semiconductor member according to Claim 18, wherein said non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

26. A process for preparing a semiconductor member according to Claim 18, wherein said porous monocrystalline semiconductor region is obtained by making the non-porous semiconductor monocrystalline region porous by anodization.

27. A process for preparing a semiconductor member according to Claim 18, wherein said anodization is carried out in an HF solution.

28. A process for preparing a semiconductor member according to Claim 19, wherein said non-porous monocrystalline semiconductor region is intrinsic or

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N-type.

29. A process for preparing a semiconductor member according to Claim 28, wherein said N-type silicon is formed by proton irradiation or epitaxial growth.

30. A process for preparing a semiconductor member according to Claim 18, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

31. A process for preparing a semiconductor member according to Claim 18, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

32. A process for preparing a semiconductor member according to Claim 18, wherein etching of said porous monocrystalline semiconductor region is carried out under the state where the members bonded to each other are covered with an anti-etching material.

33. A process for preparing a semiconductor member according to Claim 32, wherein said anti-

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etching material is silicon nitride.

34. A process for preparing a semiconductor member according to Claim 32, wherein said anti-etching material is Apiezon Wax.

35. A process for preparing a semiconductor member comprising the steps of:

making a non-porous monocrystalline semiconductor member porous to form a porous monocrystalline semiconductor region,

forming a non-porous monocrystalline semiconductor region on said porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of said non-porous monocrystalline semiconductor region, and

removing said porous monocrystalline semiconductor region by etching.

36. A process for preparing a semiconductor member according to Claim 35, wherein said monocrystalline semiconductor comprises silicon.

37. A process for preparing a semiconductor

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member according to Claim 35, wherein said porous monocrystalline semiconductor region is P-type.

38. A process for preparing a semiconductor member according to Claim 35, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

39. A process for preparing a semiconductor member according to Claim 35, wherein said bonding step is carried out in an atmosphere containing nitrogen.

40. A process for preparing a semiconductor member according to Claim 35, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

41. A process for preparing a semiconductor member according to Claim 35, wherein said non-porous monocrystalline semiconductor region is formed by epitaxial growth.

42. A process for preparing a semiconductor member according to Claim 35, wherein said non-porous monocrystalline semiconductor region is formed

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according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

43. A process for preparing a semiconductor member according to Claim 35, wherein said porous monocrystalline semiconductor region is obtained by anodization.

44. A process for preparing a semiconductor member according to Claim 43, wherein said anodization is carried out in an HF solution.

45. A process for preparing a semiconductor member according to Claim 36, wherein said non-porous monocrystalline semiconductor region is intrinsic or N-type.

46. A process for preparing a semiconductor member according to Claim 45, wherein said N-type silicon is formed by epitaxial growth.

47. A process for preparing a semiconductor member according to Claim 35, wherein the member of which the surface is constituted of an insulating

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substance comprises a light-transmissive material.

48. A process for preparing a semiconductor member according to Claim 35, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

49. A process for preparing a semiconductor member comprising the steps of:

making a non-porous monocrystalline semiconductor member porous to form a porous monocrystalline semiconductor region,

forming a non-porous monocrystalline semiconductor region on said porous monocrystalline semiconductor region,

forming region constituted of an insulating substance on said non-porous monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of said region constituted of the insulating substance, and

removing said porous monocrystalline semiconductor region by etching.

50. A process for preparing a semiconductor

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member according to Claim 49, wherein said monocrystalline semiconductor comprises silicon.

51. A process for preparing a semiconductor member according to Claim 49, wherein said porous monocrystalline semiconductor region is P-type.

52. A process for preparing a semiconductor member according to Claim 49, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

53. A process for preparing a semiconductor member according to Claim 49, wherein said bonding step is carried out in an atmosphere containing nitrogen.

54. A process for preparing a semiconductor member according to Claim 49, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

55. A process for preparing a semiconductor member according to Claim 49, wherein said non-porous monocrystalline semiconductor region is formed by epitaxial growth.

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56. A process for preparing a semiconductor member according to Claim 49, wherein said non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

57. A process for preparing a semiconductor member according to Claim 49, wherein said porous monocrystalline semiconductor region is obtained by anodization.

58. A process for preparing a semiconductor member according to Claim 57, wherein said anodization is carried out in an HF solution.

59. A process for preparing a semiconductor member accoding to Claim 50, wherein said non-porous monocrystalline semiconductor region is intrinsic or N-type.

60. A process for preparing a semiconductor member according to Claim 59, wherein said N-type silicon is formed by epitaxial growth.

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61. A process for preparing a semiconductor member according to Claim 49, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

62. A process for preparing a semiconductor member according to Claim 49, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

63. A process for preparing a semiconductor member comprising the steps of:

making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region,

forming a third non-porous monocrystalline semiconductor region on said porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of said third non-porous monocrystalline semiconductor region, and

removing said second non-porous

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monocrystalline semiconductor region by mechanical polishing, and removing said porous monocrystalline semiconductor region by etching.

64. A process for preparing a semiconductor member according to Claim 63, wherein said monocrystalline semiconductor comprises silicon.

65. A process for preparing a semiconductor member according to Claim 63, wherein said porous monocrystalline semiconductor region is P-type.

66. A process for preparing a semiconductor member according to Claim 63, wherein said third non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

67. A process for preparing a semiconductor member according to Claim 63, wherein said bonding step is carried out in an atmosphere containing nitrogen.

68. A process for preparing a semiconductor member according to Claim 63, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

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69. A process for preparing a semiconductor member according to Claim 63, wherein said third non-porous monocrystalline semiconductor region is formed by epitaxial growth.

70. A process for preparing a semiconductor member according to Claim 63, wherein said third non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

71. A process for preparing a semiconductor member according to Claim 63, wherein said porous monocrystalline semiconductor region is obtained by anodization.

72. A process for preparing a semiconductor member according to Claim 71, wherein said anodization is carried out in an HF solution.

73. A process for preparing a semiconductor member accoding to Claim 64, wherein said third non-porous monocrystalline semiconductor region is

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intrinsic or N-type.

74. A process for preparing a semiconductor member according to Claim 73, wherein said N-type silicon is formed by epitaxial growth.

75. A process for preparing a semiconductor member according to Claim 63, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

76. A process for preparing a semiconductor member according to Claim 63, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

77. A process for preparing a semiconductor member comprising the steps of:

making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region,

forming a third non-porous monocrystalline semiconductor region on said porous monocrystalline

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semiconductor region,

forming a region constituted of an insulating substance on said third non-porous monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of said region constituted of the insulating substance, and

removing said second non-porous monocrystalline semiconductor by mechanical polishing, and removing said porous monocrystalline semiconductor region by etching.

78. A process for preparing a semiconductor member according to Claim 77, wherein said monocrystalline semiconductor comprises silicon.

79. A process for preparing a semiconductor member according to Claim 77, wherein said porous monocrystalline semiconductor region is P-type.

80. A process for preparing a semiconductor member according to Claim 77, wherein said third non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

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81. A process for preparing a semiconductor member according to Claim 77, wherein said bonding step is carried out in an atmosphere containing nitrogen.

82. A process for preparing a semiconductor member according to Claim 77, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

83. A process for preparing a semiconductor member according to Claim 77, wherein said third non-porous monocrystalline semiconductor region is formed by epitaxial growth.

84. A process for preparing a semiconductor member according to Claim 77, wherein said third non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

85. A process for preparing a semiconductor member according to Claim 77, wherein said porous monocrystalline semiconductor region is obtained by

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anodization.

86. A process for preparing a semiconductor member according to Claim 85, wherein said anodization is carried out in an HF solution.

87. A process for preparing a semiconductor member accoding to Claim 78, wherein said third non-porous monocrystalline semiconductor region is intrinsic or N-type.

88. A process for preparing a semiconductor member according to Claim 87, wherein said N-type silicon is formed by epitaxial growth.

89. A process for preparing a semiconductor member according to Claim 77, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

90. A process for preparing a semiconductor member according to Claim 77, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

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91. A process for preparing a semiconductor member comprising the steps of:

forming a second monocrystalline semiconductor region of a second electroconduction type on a first monocrystalline semiconductor region of a first electroconduction type,

making said first monocrystalline semiconductor region porous to form a porous single crysalline semiconductor region,

bonding the surface of a member of which the surface is formed of an insulating substance onto the surface of said second single crystlline semiconductor region, and

removing said porous monocrystalline semiconductor region by etching.

92. A process for preparing a semiconductor member according to Claim 91, wherein said monocrystalline semiconductor comprises silicon.

93. A process for preparing a semiconductor member according to Claim 91, wherein said first monocrystalline semiconductor region is P-type.

94. A process for preparing a semiconductor member according to Claim 91, wherein said bonding

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step is carried out in an atmosphere containing nitrogen.

95. A process for preparing a semiconductor member according to Claim 91, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

96. A process for preparing a semiconductor member according to Claim 91, wherein said second non-porous monocrystalline semiconductor region is formed by epitaxial growth.

97. A process for preparing a semiconductor member according to Claim 91, wherein said second non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

98. A process for preparing a semiconductor member according to Claim 91, wherein said porous monocrystalline semiconductor region is obtained by anodization.

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99. A process for preparing a semiconductor member according to Claim 98, wherein said anodization is carried out in an HF solution.

100. A process for preparing a semiconductor member according to Claim 92, wherein said second non-porous monocrystalline semiconductor region is intrinsic or N-type.

101. A process for preparing a semiconductor member according to Claim 100, wherein said N-type silicon is formed by epitaxial growth.

102. A process for preparing a semiconductor member according to Claim 91, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

103. A process for preparing a semiconductor member according to Claim 91, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

104. A process for preparing a semiconductor member comprising the steps of:

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forming a second monocrystalline semiconductor region of a second electroconduction type on a first monocrystalline semiconductor region of a first electroconduction type,

making said first monocrystalline semiconductor region porous to form a porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on said second monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is formed of an insulating substance onto the surface of said region constituted of an insulating substance, and

removing said porous monocrystalline semiconductor region by etching.

105. A process for preparing a semiconductor member according to Claim 104, wherein said monocrystalline semiconductor comprises silicon.

106. A process for preparing a semiconductor member according to Claim 104, wherein said first non-monocrystalline semiconductor region is P-type.

107. A process for preparing a semiconductor member according to Claim 104, wherein said non-porous

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monocrystalline semiconductor region has a thickness of 50 microns or less.

108. A process for preparing a semiconductor member according to Claim 104, wherein said bonding step is carried out in an atmosphere containing nitrogen.

109. A process for preparing a semiconductor member according to Claim 104, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.

110. A process for preparing a semiconductor member according to Claim 104, wherein said second non-porous monocrystalline semiconductor region is formed by epitaxial growth.

111. A process for preparing a semiconductor member according to Claim 104, wherein said second non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

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112. A process for preparing a semiconductor member according to Claim 104, wherein said porous monocrystalline semiconductor region is obtained by anodization.

113. A process for preparing a semiconductor member according to Claim 112, wherein said anodization is carried out in an HF solution.

114. A process for preparing a semiconductor member accoding to Claim 105, wherein said second non-porous monocrystalline semiconductor region is intrinsic or N-type.

115. A process for preparing a semiconductor member according to Claim 114, wherein said N-type silicon is formed by proton irradiation or epitaxial growth.

116. A process for preparing a semiconductor member according to Claim 104, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

117. A process for preparing a semiconductor member according to Claim 104, wherein the member of

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which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.

118. A semiconductor member comprising:

a first member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region, and

a second member having the surface constituted of an insulating substance bonded onto the surface of said non-porous monocrystalline semiconductor region.

119. A semiconductor member according to Claim 118, wherein said monocrystalline semiconductor comprises silicon.

120. A semiconductor member according to Claim 118, wherein said porous monocrystalline semiconductor region is P-type.

121. A semiconductor member according to Claim 118, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

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122. A semiconductor member comprising:

a first member having a non-porous monocrystalline semiconductor region and a region constituted of an insulating substance arranged in this order on a porous monocrystalline semiconductor region, and

a second member bonded through a region constituted of an insulating substance onto the surface of said region constituted of the insulating substance.

123. A semiconductor member according to Claim 122, wherein said monocrystalline semiconductor comprises silicon.

124. A semiconductor member according to Claim 122, wherein said porous monocrystalline semiconductor region is P-type.

125. A semiconductor member according to Claim 122, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

126. A semiconductor member having a non-porous silicon monocrystalline semiconductor region arranged

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on a region constituted of an insulating substance, characterized in that the dislocation defect density in said non-porous silicon monocrystalline semiconductor region is $2.0 \times 10^{4}/cm^{2}$ or less, and the life time of carriers is 5.0×10^{-4} sec or longer.

127. A semiconductor member having a non-porous silicon monocrystalline semiconductor region arranged on a region constituted of an insulating substance, characterized in that the dislocation defect density in said non-porous silicon monocrystalline semiconductor region is $2.0 \times 10^{4}/cm^{2}$ or less, and the life time of carriers is 5.0×10^{-4} sec or longer, and also the difference between the maximum value and the minimum value of the thickness of said silicon monocrystalline semiconductor region is 10% or less based on said maximum value.

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ABSTRACT

SEMICONDUCTOR MEMBER AND PROCESS FOR PREPARING SEMICONDUCTOR MEMBER

A process for preparing a semiconductor member comprises the steps of:

forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and then

removing the porous monocrystalline semiconductor region by etching.

(FIGURE 1A-1C)

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FIG. 1A

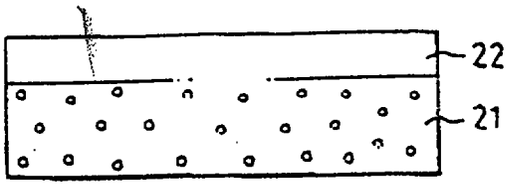


FIG. 1B

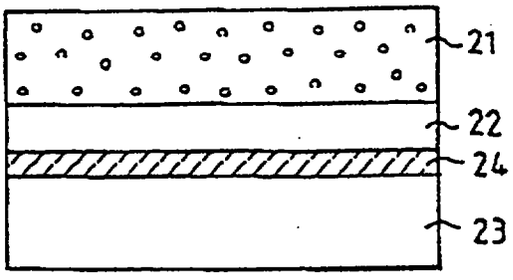


FIG. 1C

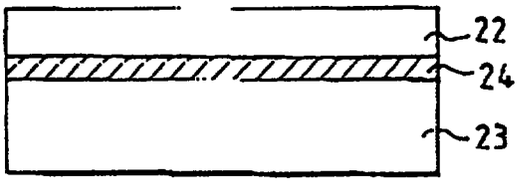


FIG. 2A

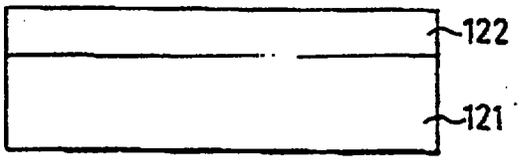


FIG. 2B

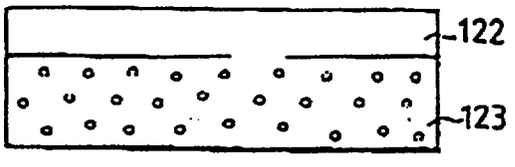


FIG. 2C

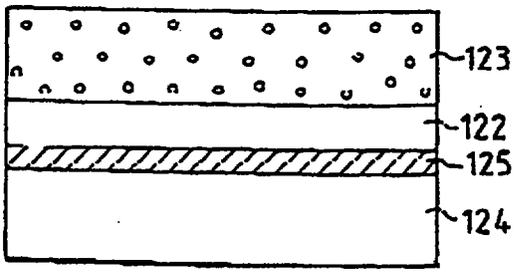
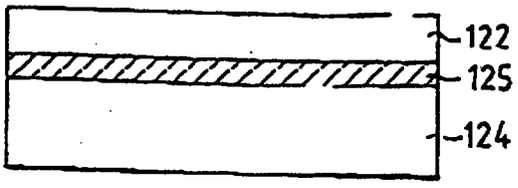


FIG. 2D



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FIG. 3A

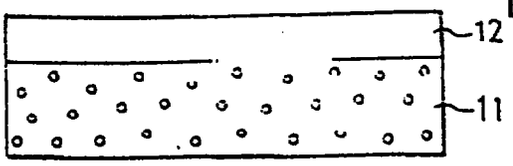


FIG. 3B

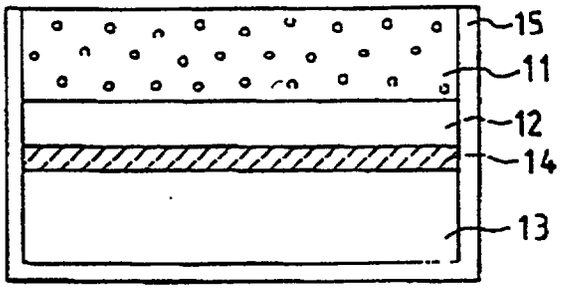


FIG. 3C

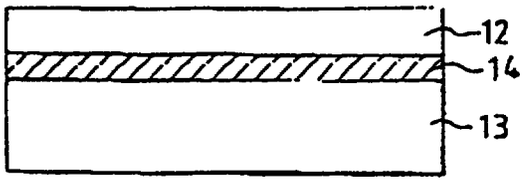


FIG. 4A

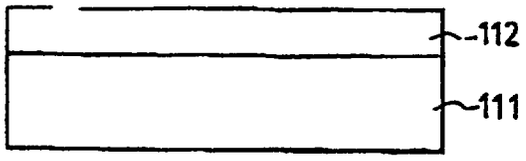


FIG. 4B

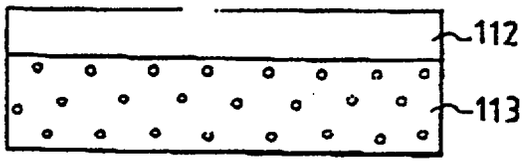


FIG. 4C

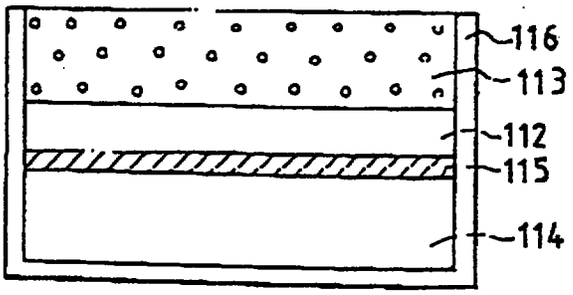
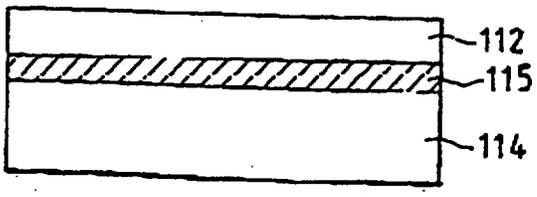


FIG. 4D



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FIG. 5A

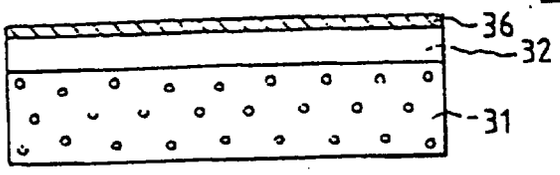


FIG. 5B

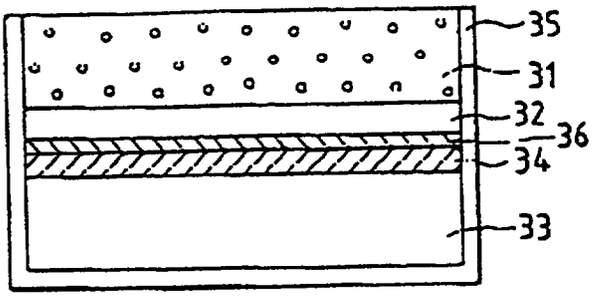


FIG. 5C

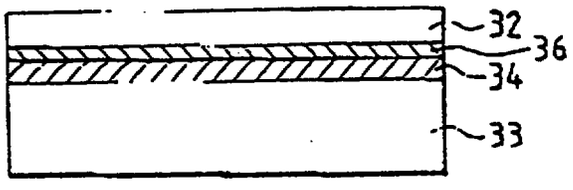


FIG. 6A

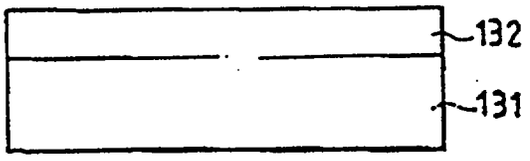


FIG. 6B

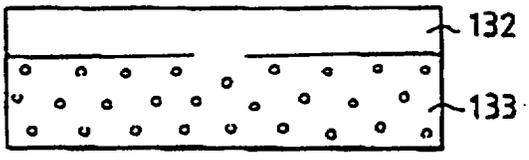


FIG. 6C

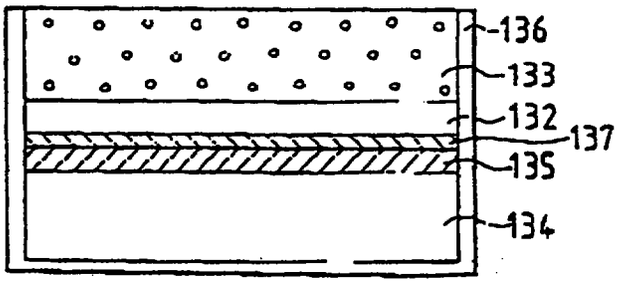
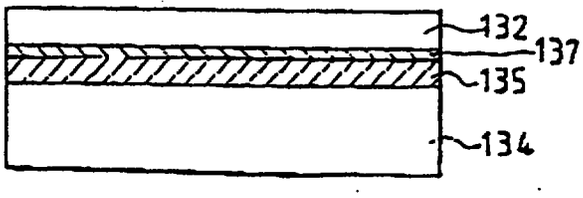


FIG. 6D



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FIG. 7A

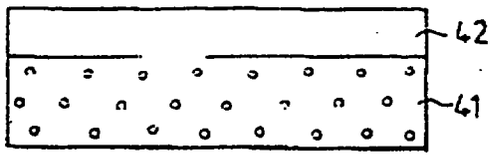


FIG. 7B

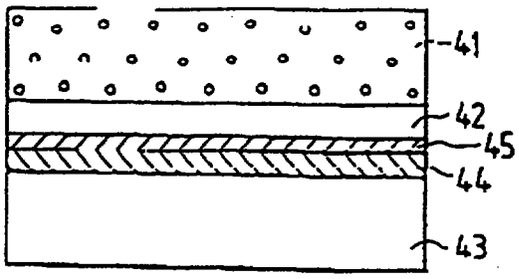


FIG. 7C

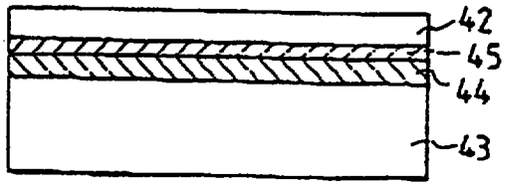


FIG. 8A

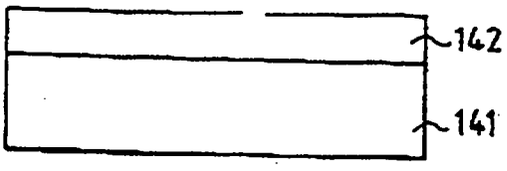


FIG. 8B

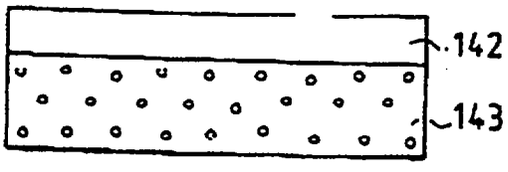


FIG. 8C

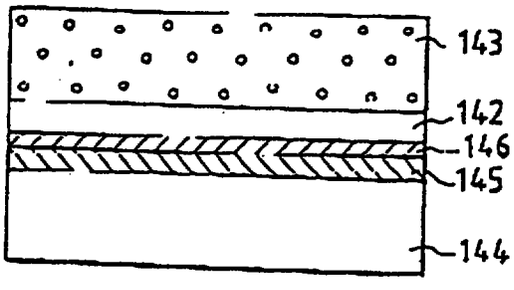
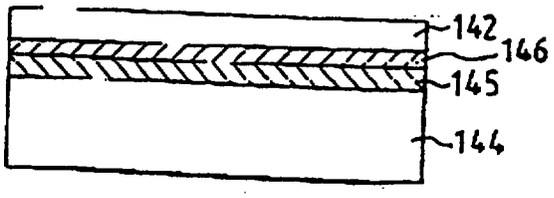


FIG. 8D



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FIG. 9A

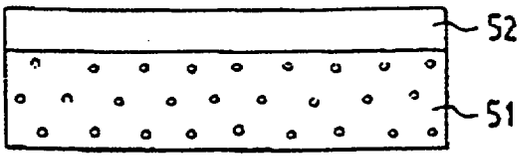


FIG. 9B

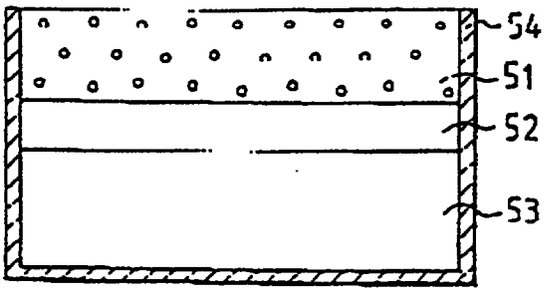


FIG. 9C

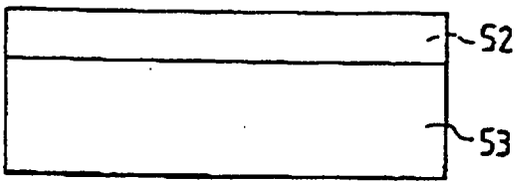


FIG. 10A

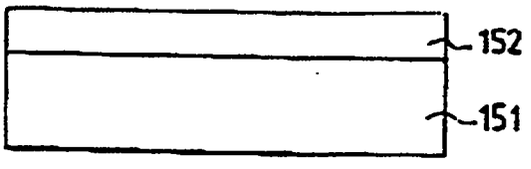


FIG. 10B

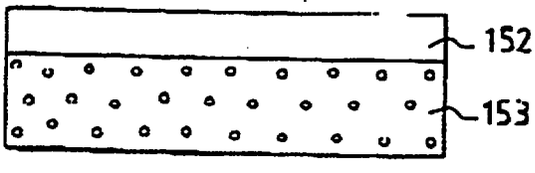


FIG. 10C

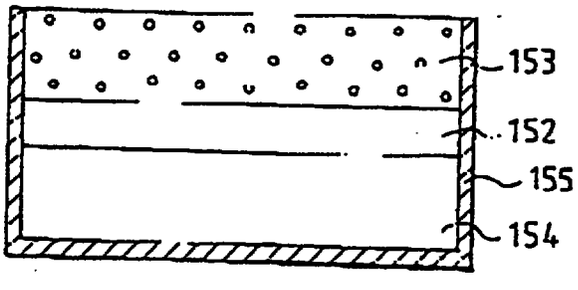
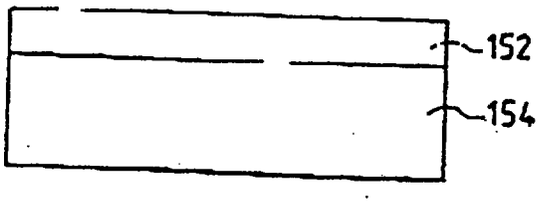


FIG. 10D



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FIG. 11A

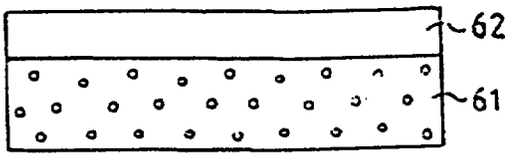


FIG. 11B

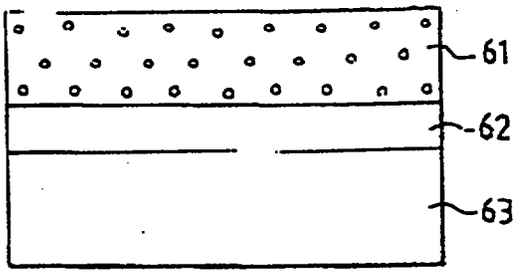


FIG. 11C

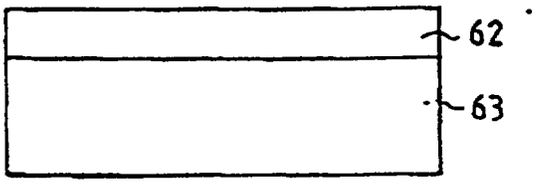


FIG. 12A

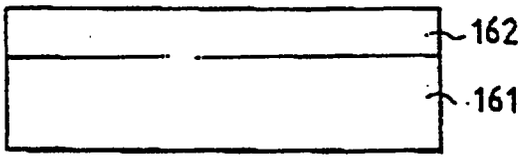


FIG. 12B

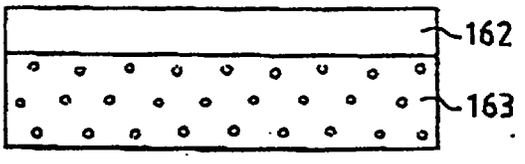


FIG. 12C

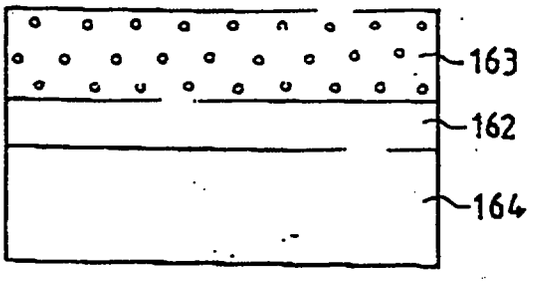
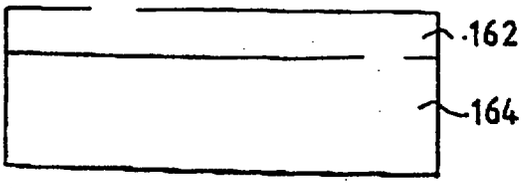


FIG. 12D



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FIG. 13A

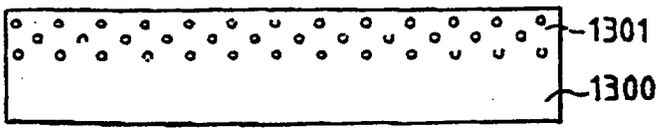


FIG. 13B

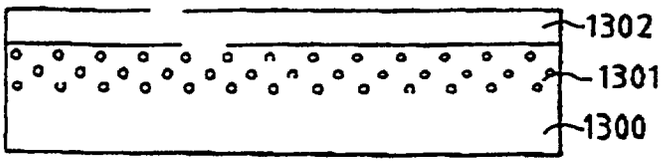


FIG. 13C

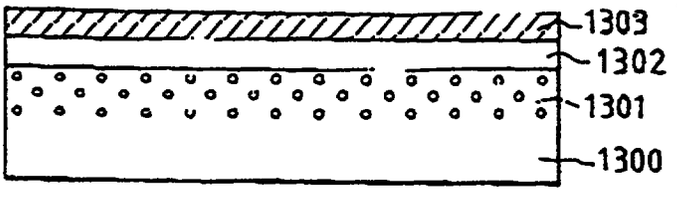


FIG. 13D

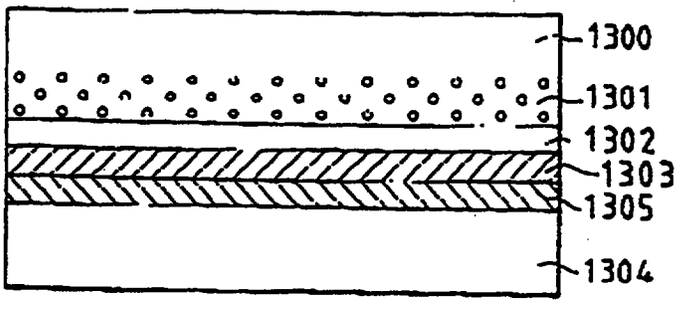


FIG. 13E

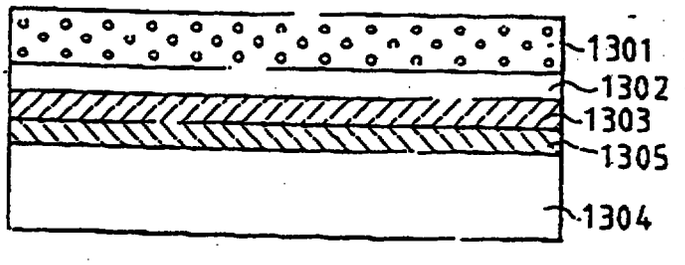
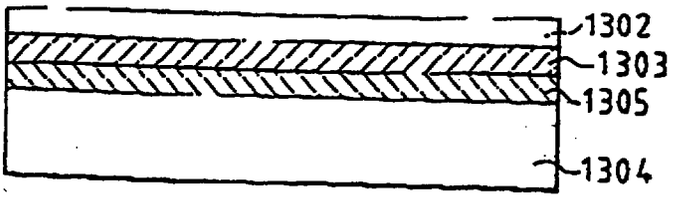


FIG. 13F



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CLAIM SHEET

1. A process for preparing a semiconductor member which comprises the steps of:

providing a first member having a porous monocrystalline semiconductor layer and a non-porous monocrystalline semiconductor layer;

bonding the first member to a second member with an insulating layer therebetween and in a manner so as to place the non-porous monocrystalline semiconductor layer inside the multi-layer structure to be obtained; and

removing the porous monocrystalline semiconductor layer from the multi-layer structure.

2. The process according to claim 1, wherein the porous monocrystalline semiconductor layer and the non-porous monocrystalline semiconductor layer comprise silicon.

3. The process according to claim 2, wherein the porous monocrystalline semiconductor layer is of P-type.

4. The process according to claim 1, wherein the non-porous monocrystalline semiconductor layer has a thickness of 50 microns or less.

5. The process according to claim 1, wherein the bonding step is carried out in an atmosphere comprising nitrogen.

6. The process according to claim 1, wherein the bonding step comprises a heat treatment.

7. The process acccording to claim 1, wherein the non-porous monocrystalline semiconductor layer is formed by epitaxial growth.

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8. The process according to claim 1, wherein the non-porous monocrystalline semiconductor layer is formed according to a method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method and the sputtering method.

9. The process according to claim 1, wherein the porous monocrystalline semiconductor layer is obtained by making porous a non-porous monocrystalline semiconductor by anodization.

10. The process according to claim 9, wherein the anodization is carried out in an HF solution.

11. The process according to claim 2, wherein the non-porous monocrystalline semiconductor layer is intrinsic or of N-type.

12. The process according to claim 11, wherein the N-type silicon is formed by proton irradiation or epitaxial growth.

13. The process according to claim 1, wherein the second member comprises a silicon substrate.

14. The process according to claim 1, wherein the second member and the insulating layer are formed by oxidizing a surface of a silicon substrate.

15. The process according to claim 1, wherein the first member and the insulating layer are formed by oxidizing a surface of a non-porous monocrystalline silicon layer of a substrate having a porous monocrystalline silicon layer and the non-porous monocrystalline silicon layer.

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16. The process according to claim 1, wherein the insulating layer comprises a first and a second insulating layers, wherein the first member and the first insulating layer are formed by oxidizing a surface of a non-porous monocrystalline silicon layer of a substrate having a porous monocrystalline silicon layer and the non-porous monocrystalline silicon layer, and wherein the second member and the second insulating layer are formed by oxidizing a surface of a silicon substrate.

17. The process according to any one of claims 14 to 16, wherein the oxidation is thermal oxidation.

18. The process according to claim 1, wherein the removal of the porous monocrystalline semiconductor layer is carried out by etching.

19. The process according to claim 18, wherein the etching is carried out by using an aqueous solution as an etchant.

20. The process according to claim 19, wherein the etchant comprises hydrofluoric acid.

21. The process according to any one of claims 1 to 20, wherein the first member is obtained by making porous a non-porous monocrystalline semiconductor to form the porous monocrystalline semiconductor layer and then forming the non-porous monocrystalline semiconductor layer on the porous monocrystalline semiconductor layer.

22. The process according to any one of claims 1 to 20, wherein the first member is obtained by forming a second monocrystalline semiconductor layer of a second conductivity type and then making the first monocrystalline semiconductor layer porous.

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23. The process according to any one of claims 1 to 20, wherein a non-porous monocrystalline semiconductor is partly made porous to form the porous monocrystalline semiconductor layer; a non-porous monocrystalline semiconductor layer is formed on the porous monocrystalline semiconductor layer to provide the first member; after the bonding step, the portion not made porous of the non-porous monocrystalline semiconductor is removed; and the porous monocrystalline semiconductor layer is removed.

24. The process according to claim 23, wherein the portion not made porous of the non-porous monocrystalline semiconductor is mechanically removed.

25. The process according to claim 14, wherein the mechanical removal is carried out by grinding or polishing.

26. A process for preparing a semiconductor member which comprises the steps of:

providing a first member having a porous monocrystalline semiconductor layer and a non-porous monocrystalline semiconductor layer;

bonding the first member to a second member comprising an insulating material in a manner so as to place the non-porous monocrystalline semiconductor layer inside the multi-layer structure to be obtained; and

removing the porous monocrystalline semiconductor layer from the multi-layer structure.

27. The process according to claim 26, wherein the porous monocrystalline semiconductor layer and the non-porous monocrystalline semiconductor layer comprise silicon.

28. The process according to claim 27, wherein the porous monocrystalline semiconductor layer is of P-type.

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29. The process according to claim 26, wherein the non-porous monocrystalline semiconductor layer has a thickness of 50 microns or less.

30. The process according to claim 26, wherein the bonding step is carried out in an atmosphere comprising nitrogen.

31. The process according to claim 26, wherein the bonding step comprises a heat treatment.

32. The process according to claim 26, wherein the non-porous monocrystalline semiconductor layer is formed by epitaxial growth.

33. The process according to claim 26, wherein the non-porous monocrystalline semiconductor layer is formed according to a method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method and the sputtering method.

34. The process according to claim 26, wherein the porous monocrystalline semiconductor layer is obtained by making porous a non-porous monocrystalline semiconductor by anodization.

35. The process according to claim 34, wherein the anodization is carried out in an HF solution.

36. The process according to claim 27, wherein the non-porous monocrystalline semiconductor layer is intrinsic or of N-type.

37. The process according to claim 36, wherein the N-type silicon is formed by proton irradiation or epitaxial growth.

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38. The process according to claim 26, wherein the second member comprises a light-transmissive material.

39. The process according to claim 38, wherein the light-transmissive material comprises glass.

40. The process according to claim 39, wherein the glass is quartz glass.

41. The process according to claim 26, wherein the removal of the porous monocrystalline semiconductor layer is carried out by etching.

42. The process according to claim 41, wherein the etching is carried out by using an aqueous solution as an etchant.

43. The process according to claim 42, wherein the etchant comprises hydrofluoric acid.

44. The process according to any one of claims 26 to 43, wherein the first member is obtained by making porous a non-porous monocrystalline semiconductor to form the porous monocrystalline semiconductor layer and then forming the non-porous monocrystalline semiconductor layer on the porous monocrystalline semiconductor layer.

45. The process according to any one of claims 26 to 43, wherein the first member is obtained by forming a second monocrystalline semiconductor layer of a second conductivity type on a first monocrystalline semiconductor layer of a first conductivity type and then making the first monocrystalline semiconductor layer porous.

46. The process according to any one of claims 26 to 43, wherein a non-porous monocrystalline semiconductor is

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partly made porous to form the porous monocrystalline semiconductor layer; a non-porous monocrystalline semiconductor layer is formed on the porous monocrystalline semiconductor layer to provide the first member; after the bonding step, the portion not made porous of the non-porous monocrystalline semiconductor is removed; and the porous monocrystalline semiconductor layer is removed.

47. The process according to claim 46, wherein the portion not made porous of the non-porous monocrystalline semiconductor is mechanically removed.

48. The process according to claim 47, wherein the mechanical removal is carried out by grinding or polishing.

49. A semiconductor member prepared by the process of any one of claims 1 to 48.

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CLAIM SHEET

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1. A process for preparing a semiconductor member which comprises the steps of:

providing a first member having a porous monocrystalline semiconductor layer and a non-porous monocrystalline semiconductor layer;

bonding the first member to a second member with an insulating layer therebetween and in a manner so as to place the non-porous monocrystalline semiconductor layer inside the multi-layer structure to be obtained; and

removing the porous monocrystalline semiconductor layer from the multi-layer structure.

2. The process according to claim 1, wherein the porous monocrystalline semiconductor layer and the non-porous monocrystalline semiconductor layer comprise silicon.

3. The process according to claim 2, wherein the porous monocrystalline semiconductor layer is of P-type.

4. The process according to claim 1, wherein the non-porous monocrystalline semiconductor layer has a thickness of 50 microns or less.

5. The process according to claim 1, wherein the bonding step is carried out in an atmosphere comprising nitrogen.

6. The process according to claim 1, wherein the bonding step comprises a heat treatment.

7. The process acccording to claim 1, wherein the non-porous monocrystalline semiconductor layer is formed by epitaxial growth.

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8. The process according to claim 1, wherein the non-porous monocrystalline semiconductor layer is formed according to a method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method and the sputtering method.

9. The process according to claim 1, wherein the porous monocrystalline semiconductor layer is obtained by making porous a non-porous monocrystalline semiconductor by anodization.

10. The process according to claim 9, wherein the anodization is carried out in an HF solution.

11. The process according to claim 2, wherein the non-porous monocrystalline semiconductor layer is intrinsic or of N-type.

12. The process according to claim 11, wherein the N-type silicon is formed by proton irradiation or epitaxial growth.

13. The process according to claim 1, wherein the second member comprises a silicon substrate.

14. The process according to claim 1, wherein the second member and the insulating layer are formed by oxidizing a surface of a silicon substrate.

15. The process according to claim 1, wherein the first member and the insulating layer are formed by oxidizing a surface of a non-porous monocrystalline silicon layer of a substrate having a porous monocrystalline silicon layer and the non-porous monocrystalline silicon layer.

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16. The process according to claim 1, wherein the insulating layer comprises a first and a second insulating layers, wherein the first member and the first insulating layer are formed by oxidizing a surface of a non-porous monocrystalline silicon layer of a substrate having a porous monocrystalline silicon layer and the non-porous monocrystalline silicon layer, and wherein the second member and the second insulating layer are formed by oxidizing a surface of a silicon substrate.

17. The process according to any one of claims 14 to 16, wherein the oxidation is thermal oxidation.

18. The process according to claim 1, wherein the removal of the porous monocrystalline semiconductor layer is carried out by etching.

19. The process according to claim 18, wherein the etching is carried out by using an aqueous solution as an etchant.

20. The process according to claim 19, wherein the etchant comprises hydrofluoric acid.

21. The process according to any one of claims 1 to 20, wherein the first member is obtained by making porous a non-porous monocrystalline semiconductor to form the porous monocrystalline semiconductor layer and then forming the non-porous monocrystalline semiconductor layer on the porous monocrystalline semiconductor layer.

22. The process according to any one of claims 1 to 20, wherein the first member is obtained by forming a second monocrystalline semiconductor layer of a second conductivity type and then making the first monocrystalline semiconductor layer porous.

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23. The process according to any one of claims 1 to 20, wherein a non-porous monocrystalline semiconductor is partly made porous to form the porous monocrystalline semiconductor layer; a non-porous monocrystalline semiconductor layer is formed on the porous monocrystalline semiconductor layer to provide the first member; after the bonding step, the portion not made porous of the non-porous monocrystalline semiconductor is removed; and the porous monocrystalline semiconductor layer is removed.

24. The process according to claim 23, wherein the portion not made porous of the non-porous monocrystalline semiconductor is mechanically removed.

25. The process according to claim 14, wherein the mechanical removal is carried out by grinding or polishing.

26. A process for preparing a semiconductor member which comprises the steps of:

providing a first member having a porous monocrystalline semiconductor layer and a non-porous monocrystalline semiconductor layer;

bonding the first member to a second member comprising an insulating material in a manner so as to place the non-porous monocrystalline semiconductor layer inside the multi-layer structure to be obtained; and

removing the porous monocrystalline semiconductor layer from the multi-layer structure.

27. The process according to claim 26, wherein the porous monocrystalline semiconductor layer and the non-porous monocrystalline semiconductor layer comprise silicon.

28. The process according to claim 27, wherein the porous monocrystalline semiconductor layer is of P-type.

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29. The process according to claim 26, wherein the non-porous monocrystalline semiconductor layer has a thickness of 50 microns or less.

30. The process according to claim 26, wherein the bonding step is carried out in an atmosphere comprising nitrogen.

31. The process according to claim 26, wherein the bonding step comprises a heat treatment.

32. The process according to claim 26, wherein the non-porous monocrystalline semiconductor layer is formed by epitaxial growth.

33. The process according to claim 26, wherein the non-porous monocrystalline semiconductor layer is formed according to a method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method and the sputtering method.

34. The process according to claim 26, wherein the porous monocrystalline semiconductor layer is obtained by making porous a non-porous monocrystalline semiconductor by anodization.

35. The process according to claim 34, wherein the anodization is carried out in an HF solution.

36. The process according to claim 27, wherein the non-porous monocrystalline semiconductor layer is intrinsic or of N-type.

37. The process according to claim 36, wherein the N-type silicon is formed by proton irradiation or epitaxial growth.

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38. The process according to claim 26, wherein the second member comprises a light-transmissive material.

39. The process according to claim 38, wherein the light-transmissive material comprises glass.

40. The process according to claim 39, wherein the glass is quartz glass.

41. The process according to claim 26, wherein the removal of the porous monocrystalline semiconductor layer is carried out by etching.

42. The process according to claim 41, wherein the etching is carried out by using an aqueous solution as an etchant.

43. The process according to claim 42, wherein the etchant comprises hydrofluoric acid.

44. The process according to any one of claims 26 to 43, wherein the first member is obtained by making porous a non-porous monocrystalline semiconductor to form the porous monocrystalline semiconductor layer and then forming the non-porous monocrystalline semiconductor layer on the porous monocrystalline semiconductor layer.

45. The process according to any one of claims 26 to 43, wherein the first member is obtained by forming a second monocrystalline semiconductor layer of a second conductivity type on a first monocrystalline semiconductor layer of a first conductivity type and then making the first monocrystalline semiconductor layer porous.

46. The process according to any one of claims 26 to 43, wherein a non-porous monocrystalline semiconductor is

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partly made porous to form the porous monocrystalline semiconductor layer; a non-porous monocrystalline semiconductor layer is formed on the porous monocrystalline semiconductor layer to provide the first member; after the bonding step, the portion not made porous of the non-porous monocrystalline semiconductor is removed; and the porous monocrystalline semiconductor layer is removed.

47. The process according to claim 46, wherein the portion not made porous of the non-porous monocrystalline semiconductor is mechanically removed.

48. The process according to claim 47, wherein the mechanical removal is carried out by grinding or polishing.

49. A semiconductor member prepared by the process of any one of claims 1 to 48.

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SEMICONDUCTOR MEMBER AND PROCESS FOR PREPARING SEMICONDUCTOR MEMBER

ABSTRACT OF THE DISCLOSURE

A process for preparing a semiconductor member comprises the steps of:

forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and then

removing the porous monocrystalline semiconductor region by etching.

FIGURES 1A to 1C

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