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SEMICONDUCTOR MEMBER AND PROCESS FOR PREPARING
SEMICONDUCTOR MEMBER

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1 Semiconductor Member and Process for
Preparing Semiconductor Member

BACKGROUND OF THE INVENTION

5 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;



- 1 3. Stray capacity is reduced to attain high speed;
4. Well formation step can be omitted;
5. Latch-up can be prevented;
- 5 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
10 structure for these some 10 years. The contents are summarized in, for example, the literature as mentioned below:

Spécial Issue: "Single-crystal silicon on non-single-crystal insulators"; edited by G.W. Cullen,
15 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
20 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
25 substrate, introduction of aluminum from the sapphire substrate into the Si layer, and above all the high



1 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
5 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
10 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
15 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
20 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
25 epitaxial growth by CVD, the method in which amorphous
Si is deposited and subjected to solid phase lateral



1 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
5 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
methode have both advantages and disadvantages, the
10 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
15 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,
20 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
25 defect (sub-boundary), etc. remain, and no device
driven by minority carriers has been prepared.



1 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.

5 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
10 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
15 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
20 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
25 Si monocrystalline substrate, which is one of the most
mature methods because of good matching with the Si-IC



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1 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-
5 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
10 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
15 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
20 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
25 exerted on the monocrystalline Si layer, and therefore
in these methods, a monocrystalline Si layer with



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

SUMMARY OF THE INVENTION

5 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.

10 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.

15 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
20 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:

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



1 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

5 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:

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

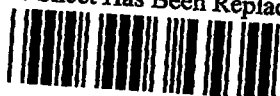
forming a region constituted of an insulating substance on the non-porous monocrystalline semiconductor side of the member, then

15 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

20 removing the porous monocrystalline semiconductor region by chemical etching:

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

25 making a non-porous monocrystalline semiconductor member porous to form a porous monocrystalline semiconductor region.



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

5 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;
10 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,

15 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
20 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

25 removing the porous monocrystalline
semiconductor region by chemical etching;



1 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
5 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,
10 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
15 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:
20 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
25 semiconductor region on the porous monocrystalline
semiconductor region,



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

5 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

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

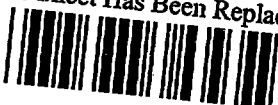
to provide a process for preparing a semiconductor member comprising the steps of:

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

20 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

25 removing the porous monocrystalline semiconductor region by chemical etching;



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1 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
5 monocrystalline semiconductor region of a first
electroconduction type,

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

10 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
15 surface of the second monocrystalline semiconductor
region, and

removing the porous monocrystalline
semiconductor region by chemical etching;

to provide a semiconductor member comprising:
20 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
25 surface of the non-porous monocrystalline
semiconductor region;



1 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
5 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
10 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
15 defect density in the non-porous silicon
monocrystalline semiconductor region is $2.0 \times 10^4/\text{cm}^2$
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-
20 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 $2.0 \times 10^4/\text{cm}^2$
25 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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1 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

5 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

10 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
15 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
20 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
25 this order on a porous monocrystalline semiconductor
region, and



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A process for preparing a semiconductor member

1 of the present invention comprises:

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

5 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
10 semiconductor region by chemical etching.

Another process comprises:

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

15 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
20 the surface of the region constituted of the
insulating substance, and

removing the porous monocrystalline
semiconductor region by chemical etching.

Still another process comprises:

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



1

semiconductor region on the porous monocrystalline
semiconductor region,

5

10

Still another process comprises the steps of:

semiconductor member porous to form a porous
monocrystalline semiconductor region,

15

substance on the non-porous monocrystalline
semiconductor region side,

25

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1 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-
5 porous monocrystalline semiconductor region,

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

10 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
15 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
20 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,

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



1 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

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

10 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,

15 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,

20 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

25 removing the porous monocrystalline semiconductor region by chemical etching.



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1 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
5 electroconduction type,

making the first monocrystalline semiconductor
region porous to form a porous monocrystalline
semiconductor region,
forming a region constituted of an insulating
10 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
15 substance, and

removing the porous monocrystalline
semiconductor region by chemical etching.

The semiconductor member of the present
invention has a monocrystalline semiconductor region
20 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
25 capable of high speed response, and is applicable to
semiconductor devices rich in reliability. The



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

5 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.

10 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.

15 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.

20 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.

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



1 the present invention is not limited to silicon at
all.

5 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
10 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
15 part, thus being monocrystalline. And, epitaxial
growth of a monocrystalline Si layer onto the porous
layer is possible. However, at a temperature of 1000
°C or higher, rearrangement of the atoms positioned
around the inner pores takes place, whereby the
20 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
25 epitaxial growth, plasma CVD, low pressure CVD method,
photo CVD, bias-sputtering method, liquid phase growth



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1 method, etc.

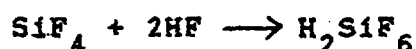
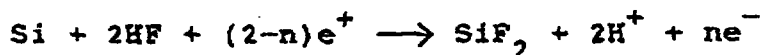
Since the porous layer has a large amount of voids formed internally thereof, its density can be reduced to half or lower. As the result, the surface area per unit volume (specific surface area) can be dramatically increased, and therefore its chemical etching rate is remarkably accelerated as compared 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.

20 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)).

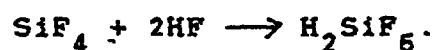
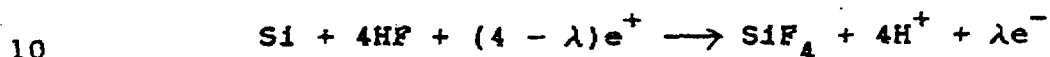
Unagami et al. studied about the dissolving



1 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,
5 p. 476 (1980)).



or



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
15 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
20 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
Taushin Gakkai Gijutsu Kenkyu Hokoku, vol. 79, SSD 79-
25 9549(1979)) and Imai, (K. Imai; Solid-State
Electronics vol. 24, 159 (1981)). However, depending



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1 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.

5 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.

10 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
15 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/cm³
20 by varying the HF solution concentration to 50 to 20% as compared with the density 2.33 g/cm³ of the monocrystalline Si.

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



1 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
5 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
10 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
15 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.

20 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
25 the above semiconductor monocrystalline layer.

Bonding between the above non porous



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1 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
5 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
10 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
15 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
20 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
25 substrates having a layer of an insulating material
such as oxide, nitride, boride, etc. formed on the

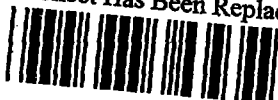


1 surface, etc. Specific examples of the substrates
wholly constituted of an insulating material may
include substrates comprising insulating materials
such as fused silica glass, sintered alumina, etc.

5 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
10 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
15 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
20 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
25 influenced by the etchant.

The non-porous monocrystalline layer on the



1 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
5 small in distribution of the layer thickness of the
semiconductor monocrystalline layer. Specifically,
the dislocation defect density becomes $2 \times 10^4/\text{cm}^2$ or
less, and concerning the layer thickness of the
semiconductor monocrystalline layer, within the range
10 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
15 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.

20 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
25 to form an N-type monocrystalline layer 122.

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



1 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
5 range of 1.1 to 0.6 g/cm³ 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/cm³. The porous layer, as described above, is
formed on the P-type substrate.

10 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
15 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 SiO₂ layer 125, thereby forming a
semiconductor substrate.

20 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
25 with a large area.

The semiconductor substrate thus obtained can



1 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
5 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
10 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,
15 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
20 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
25 is deposited to cover over the whole of the bonded two
silicon wafers as the anti-etching film.



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1 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 .
5 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
10 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
15 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
20 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

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

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1 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.

5 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
10 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/cm³ by varying the HF solution concentration to 50 to 20% as compared with the
15 density of the monocrystalline Si of 2.33 g/cm³. 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
20 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
25 film 116, an Si₃N₄ layer 116 is deposited to cover over the whole of the bonded two silicon wafers as the

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1 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
5 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
10 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
15 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
20 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

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



1 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.

5 As shown in Fig. 6B, 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
10 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
15 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,
20 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
25 silicon layer 32 made into a thin film remain on the
 SiO_2 layer, thereby forming a semiconductor substrate.



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



1 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
5 1.1 to 0.6 g/cm³ by varying the HF solution
concentration to 50 to 20% as compared with the
density of the monocrystalline Si of 2.33 g/cm³. The
porous layer, as described above, is formed from the P-
type substrate.

10 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
15 layer 132 on the porous Si substrate 133.

Subsequently, as the anti-etching film 136, an
Si₃N₄ layer 136 is deposited to be coated on the
bonded two silicon wafers as a whole. Then, as shown
in Fig. 6D, the Si₃N₄ layer 136 on the surface of the
20 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 SiO₂ layers 135 and 137, thereby
forming a semiconductor substrate.

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



1 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
5 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,
10 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
15 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
20 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
25 substrate 41 is all etched to have the monocrystalline
silicon layer made into a thin film on the SiO₂ layers



1 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
5 crystallinity to silicon wafer is formed through the
SiO₂ 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
10 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

15 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
20 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.

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



1 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/cm³ by varying the HF solution
5 concentration to 50 to 20% as compared with the
density of the monocrystalline Si of 2.33 g/cm³. The
porous layer, as described above, is formed on the P-
type substrate 141.

As shown in Fig. 8C, by preparing another Si
10 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.

15 Then the porous Si substrate is all chemically
etched to have a monocrystalline silicon layer made
into a thin film remain on the SiO₂ layers 145 and
146, thereby forming a semiconductor substrate.

Fig. 8D shows the semiconductor substrate
20 obtained in the present invention. A monocrystalline
Si layer 142 equal in crystallinity to silicon wafer
is formed through the SiO₂ 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.

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



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

5 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
10 substrate S1 made porous to form a thin film
monocrystalline layer S2.

As shown in Fig. 9B, a light-transmissive
substrate S3 represented by glass is prepared and the
light-transmissive substrate S3 is bonded onto the
15 surface of the monocrystalline Si layer S2 on the
porous Si substrate S1.

Here, as shown in Fig. 9B, as the anti-etching
film S4, an Si_3N_4 layer S4 is deposited to be coated
on the bonded two substrates as a whole.
20 Subsequently, as shown in Fig. 9C, the Si_3N_4 layer S4
on the surface of the porous silicon substrate is
removed. Then, the porous Si substrate S1 is all
etched away to have a monocrystalline silicon layer S2
made into a thin film remain on the light-transmissive
25 substrate S3, thereby forming a semiconductor
substrate. Fig. 9C shows the semiconductor substrate



1 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

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.

20 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 25 1.1 to 0.6 g/cm³ by varying the HF solution concentration to 50 to 20% as compared with the



1 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-
5 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
10 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
15 152 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
20 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
25 be also used suitably also with respect to preparation
of an isolation separated electronic device with a



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

5 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
10 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
15 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
20 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
25 substrate 63, flat and yet uniformly into a thin
layer, over the whole wafer region with a large area.



1 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.

3 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
10 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
15 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
20 layer 163 can be varied in its density in the range of
1.1 to 0.6 g/cm³ by varying the HF solution
concentration to 50 to 20% as compared with the
density of the monocrystalline Si of 2.33 g/cm³. The
porous layer 163, as described above, is formed on the
25 P-type substrate 163.

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

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1 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
5 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
10 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.

15 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
20 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
25 porous region 1301 is formed on a part of an Si
monocrystalline substrate 1300. Subsequently, a thin



1 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).

5 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
10 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.
15 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
20 effected highly efficiently.

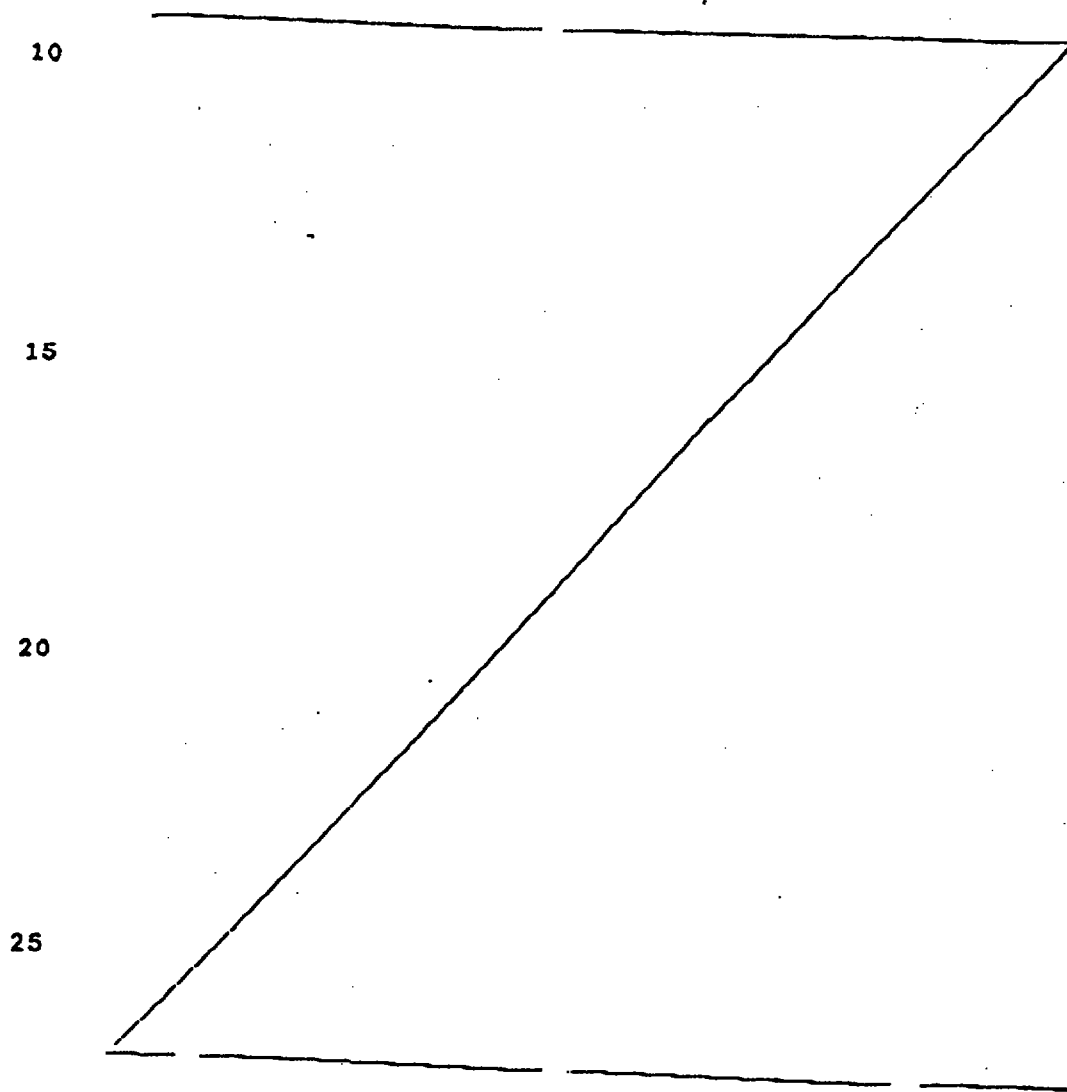
It is also possible to bond the thin film Si
monocrystalline layer 1302 directly to the oxidized
film 1305 without forming the oxidized film 1303 shown
in Fig. 13, and it is also possible to bond an
25 insulating substrate such as glass, etc. in place of
the oxidized film 1305 formed on the Si substrate



1 1304.

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

5 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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1 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
5 solution. The current density at this time was 100
 mA/cm². 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.

10 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 °C

15 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
20 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 21 was
 chemically etched away by use of hydrofluoric acid-
 nitric acid-acetic acid solution (1:3:8).

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



1 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
5 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
10 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
15 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
20 the result of plan view observation of the
monocrystalline Si layer by transmission electron
microscopy, the dislocation defect density was found
to be suppressed $1 \times 10^3/\text{cm}^2$ or less, whereby it could
be confirmed that no new crystal defect had been
25 introduced in the monocrystalline Si layer formation
step to maintain good crystallinity. When the life

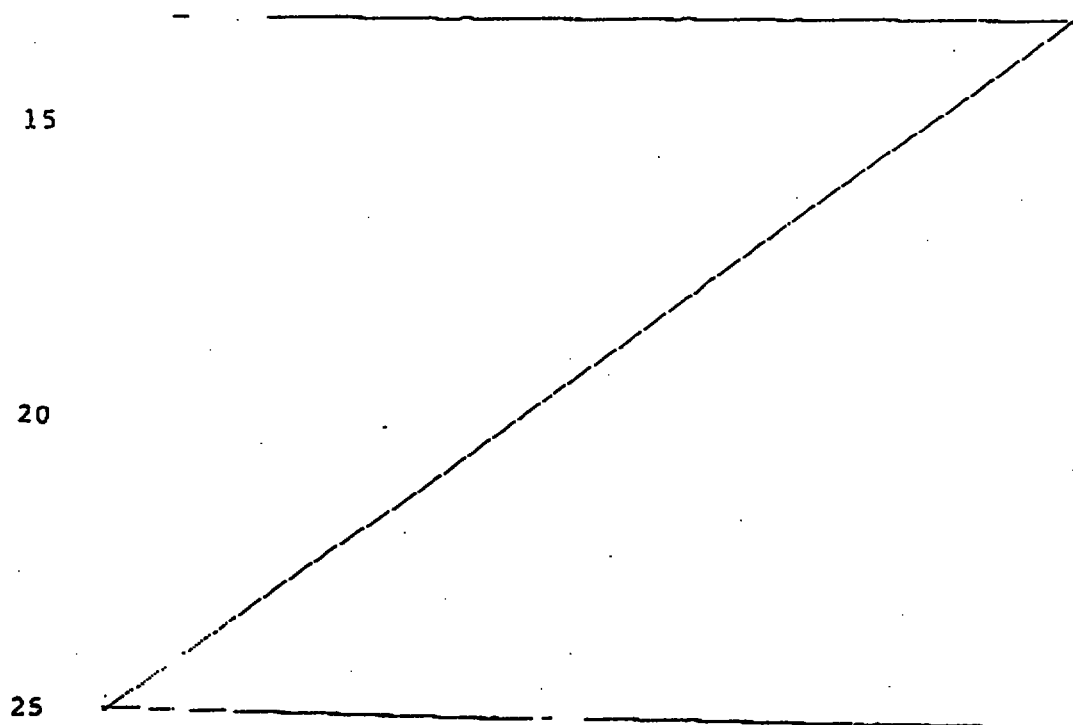


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- 1 time of minority carriers was measured for the
monocrystalline Si layer by use of the MOS C-t method,
a high value of 2.0×10^{-3} sec. was exhibited.

Example 2

- 5 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
10 $\mu\text{m/min.}$ and the P-type (100) Si substrate having a
thickness of 500 microns as a whole was made porous in
60 minutes.



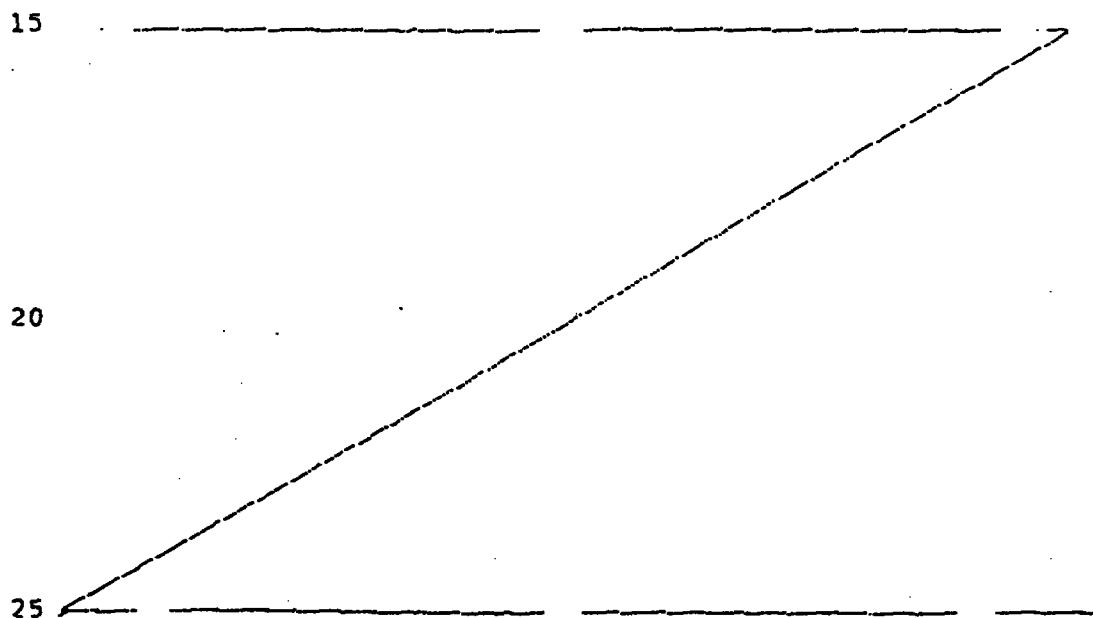
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1 On the P-type (100) porous Si substrate 21 was
grown at low temperature an Si epitaxial layer 22 to a
thickness of 0.5 microns by the plasma CVD method.
The deposition conditions are as follows:

5 Gas: SiH_4
Radio frequency power: 100 W
Temperature: 800 °C
Pressure: 1×10^{-2} Torr
Growth rate: 2.5 nm/sec.

10 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 °C for 0.5 hour, the two Si substrates were bonded



1 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).

5 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
10 by about 100-fold thereof. That is, the Si substrate
21 made porous having a thickness of 500 microns was
removed in 5 minutes.

15 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
20 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
25 the result of plan view observation of the
monocrystalline Si layer by transmission electron



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1 microscopy, the dislocation defect density was found
to be suppressed $1 \times 10^3/\text{cm}^2$ or less, whereby it could
be confirmed that no new crystal defect had been
introduced in the monocrystalline Si layer formation
5 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 3

10 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/cm². The porous structure formation rate at this
15 time was 8.4 $\mu\text{m}/\text{min}$. 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
20 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

25 Growth time: 60 minutes

Target direct current bias: - 200 V



1 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 °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).

10 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-
15 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



1 porous structure formation rate at this time was 8.4
 2 $\mu\text{m}/\text{min.}$ and the P-type (100) Si substrate having a
 3 thickness of 200 microns as a whole was made porous in
 4 24 minutes.

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

Solvent: Sn
 10 Growth temperature: 900 °C
 Growth atmosphere: H_2
 Growth time: 10 minutes.

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

21 Thus, a monocrystalline Si layer 22 having a
 22 thickness of 0.5 μm could be formed on the SiO_2 layer
 23 24.
 25

Example 5



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1 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
 5 porous structure formation rate at this time was 8.4
 $\mu\text{m/min.}$ 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
 10 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°C

15 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
 20 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 21 was
 chemically etched away by use of hydrofluoric acid-
 nitric acid-acetic acid solution (1:3:8). As the
 25 result, 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. When SiH_2Cl_2 was employed as the source gas, although it was necessary to elevate the growth temperature by some ten degrees, the accelerated 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 $^{\circ}\text{C}$

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 $\mu\text{m}/\text{min}$. 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.



1 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 0.6
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
10 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
15 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
20 electron microscopy, the dislocation defect density
was found to be suppressed $1 \times 10^3/\text{cm}^2$ 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.
25 When the life time of minority carriers was measured
for the monocrystalline Si layer by use of the



1 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
5 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
10 H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF
15 solution. The current density at this time was 100
 mA/cm^2 . The porous structure formation rate at this
time was 8.4 $\mu\text{m/min}$. 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
20 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
25 surface, and by heating in a nitrogen atmosphere at
800 °C for 0.5 hour, the two Si substrates were bonded



1 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
5 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
10 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
15 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/cm²). The substrate 121
was anodized in a 50% HF solution. The current
density at this time was 100 mA/cm². The porous
20 structure formation rate at this time was 8.4 μ m/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
25 porous, and there was no change in the N-type Si layer
122. Next, on the surface of the N-type Si layer 122



1 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
5 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.

10 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.

15 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/cm². The
20 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
25 grown an Si epitaxial layer 12 to a thickness of 0.5
microns by the MBE (Molecular Beam Epitaxy) method.



1 The deposition conditions are as follows:

Temperature: 700 °C

Pressure: 1×10^{-9} Torr

Growth rate: 0.1 nm/sec.

5 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

10 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

15 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

20 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

25 introduced in the Si layer to maintain good

crystallinity.



1 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
5 current density at this time was 100 mA/cm^2 . The
porous structure formation rate at this time was 8.4
 $\mu\text{m/min.}$ and the P-type (100) Si substrate having a
thickness of 200 microns as a whole was made porous in
24 minutes.

10 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
15 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
20 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
25 bonded substrate by the low pressure CVD method to a
thickness of $0.1 \mu\text{m.}$ Thereafter, only the silicon



1 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
5 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.

10 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
15 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
20 $1 \times 10^3/\text{cm}^2$ 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
25 by use of the MOS C-t method, a high value of 2.0×10^{-3}
sec. was exhibited.



1 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 $8.4 \text{ } \mu\text{m/min.}$ 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
15 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

20 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 25 bonded substrate by the low pressure CVD method to a



1 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
5 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
10 thickness of 0.5 μm on the SiO_2 layer 14 could be
formed.

Also, the same effect was obtained when
Aplazon Wax was coated in place of the Si_3N_4 layer,
and only the Si substrate made porous could be
15 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
20 current density at this time was 100 mA/cm^2 . The
porous structure formation rate at this time was 8.4
 $\mu\text{m/min}$. 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
25 11 was grown an Si epitaxial layer 12 to a thickness
of 0.5 microns by the liquid phase growth method. The



1 growth conditions are as follows:

Solvent: Sn

Growth temperature: 900 °C

Growth atmosphere: H₂

5 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, Si₃N₄ 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 Si₃N₄ layer 15, a substrate having a monocrystalline Si layer 12 having a thickness of 0.5 μm on the SiO₂ layer 14 could be formed.

Also, the same effect was obtained when Apiezon Wax was coated in place of the Si₃N₄ layer, and only the Si substrate made porous could be



1 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 $8.4 \mu\text{m/min}$. 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 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°C
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°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 $0.1 \mu\text{m}$. Thereafter, only the silicon



1 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
5 (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
10 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
15 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
20 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 $^{\circ}\text{C}$	
Pressure: 80 Torr	
Time: 2 min.	



1 The substrate was anodized in a 50% HF
solution. The current density at this time was 100
mA/cm². The porous structure formation rate at this
time was 8.4 μ m/min. and the P-type (100) Si substrate
5 111 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
10 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, Si₃N₄ was coated on the
15 bonded substrate by the low pressure CVD method to a
thickness of 0.1 μ m. 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-
20 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 Si₃N₄ layer 116, a substrate
having a monocrystalline Si layer 112 having a
25 thickness of 1 μ m could be formed on SiO₂.

Also the thickness of the monocrystalline Si

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1 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
5 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
10 to be suppressed $1 \times 10^3/\text{cm}^2$ 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
15 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
20 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
25 H_2 230 l/min.
Temperature: 1080 °C

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1 Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm². 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 °C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si₃N₄ 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 Si₃N₄ layer 116, a substrate having a monocrystalline Si layer 112 having

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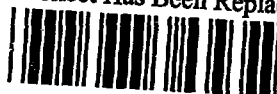


1 a thickness of 0.5 μm could be formed on the SiO_2
 layer 115. As the result of cross-sectional
 observation by transmission electron microscopy, it
 could be confirmed that no new crystal defect had been
 5 introduced in the Si layer to maintain good
 crystallinity.

Example 16

On a surface of a P-type (100) Si substrate
 111 having a diameter of 3 inches and a thickness of
 10 200 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
 15 this time was 100 mA/cm^2 . The porous structure
 formation rate at this time was 8.4 $\mu\text{m}/\text{min}$. 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
 20 111 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
 25 at 800 $^{\circ}\text{C}$ for 0.5 hour, the Si substrates were bonded
 firmly together. Subsequently, Si_3N_4 was coated on

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1 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
5 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
10 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
15 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
20 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
 $\mu\text{m}/\text{min}$. and the P-type (100) Si substrate having a
thickness of 200 microns as a whole was made porous in
25 24 minutes.

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



The deposition conditions are as follows:

5 Pressure: 1×10^9 Torr

oxide layer 34 of 5000 angstroms formed on the surface
was superposed the above oxide layer 36, and by

coated on the bonded substrate by the low pressure CVD
15 method to a thickness of 0.1 μm . Thereafter, only the

removed by reactive ion etching. Then, the porous Si

hydrofluoric acid-nitric acid-acetic acid solution

20 (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

25 cross-sectional observation by transmission electron
microscopy, it could be confirmed that no new crystal



1

Example 18

5

15

20

1 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
5 substrate Si was chemically etched away by use of a
KOH solution (6 M). As the result, the Si substrate
Si 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
10 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
15 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
20 the monocrystalline Si layer by transmission electron
microscopy, the dislocation defect density was found
to be suppressed $1 \times 10^3/\text{cm}^2$ or less, whereby it could
be confirmed that no new crystal defect had been
introduced in the monocrystalline Si layer formation
25 process to maintain good crystallinity. When the life
time of minority carriers was measured for the

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

Example 19

5 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
 $\mu\text{m/min.}$ and the P-type (100) Si substrate having a
10 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:

- 15 RF frequency: 100 MHz
- Radio frequency power: 600 W
- Temperature: 800°C
- Ar gas pressure: 8×10^{-3} Torr
- Growth time: 120 min.
- 20 Target direct current bias: - 200 V
- Substrate direct current 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
25 oxide layer 34 of 5000 angstroms formed on the surface
was superposed the above oxide layer 36, and by

1 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
5 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
10 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
15 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
20 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
 $\mu\text{m}/\text{min}$. and the P-type (100) Si substrate having a
25 thickness of 200 microns as a whole was made porous in
24 minutes. On the P-type (100) porous Si substrate



1 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

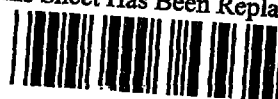
5 Growth temperature: 900 °C

Growth atmosphere: H₂

Growth time: 10 min.

Next, on the surface of the epitaxial layer 32
was formed an oxide layer 36 with a thickness of 1000
10 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. Si₃N₄ was
15 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
20 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 Si₃N₄ layer 35, a substrate
having a monocrystalline Si layer 32 could be formed
25 on the SiO₂. The same effect was obtained also when
Apiezon Wax was coated in place of the Si₃N₄ layer.

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1 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
5 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
10 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 $1 \times 10^3/\text{cm}^2$ or less, whereby it could
be confirmed that no new crystal defect had been
15 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.

20 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 $100 \text{ mA}/\text{cm}^2$. The
25 porous structure formation rate at this time was 8.4
 $\mu\text{m}/\text{min}$. and the P-type (100) Si substrate having a



1 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
5 CVD method. The deposition conditions are as follows:

Source gas: SiH_4

Carrier gas: H_2

Temperature: 850°C

Pressure: 1×10^{-2} Torr

10 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
15 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
20 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
25 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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1 substrate having a monocrystalline Si layer 32 could
be formed on the SiO₂ layer.

When SiH₂Cl₂ was employed as the source gas,
although the growth temperature was required to be
5 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
10 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: SiH₂Cl₂ 1000 SCCM
15 H₂ 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 2 min.

The substrate was anodized in a 50% HF
20 solution. The current density at this time was 100
mA/cm². 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
25 the P-type (100) Si substrate 131 was made porous in
this anodization, and there was no change in the Si



1 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
 5 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
 10 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
 15 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 .

20 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

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



1 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

5 H_2 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

Time: 1 min.

The substrate was anodized in a 50% HF
10 solution. The current density at this time was 100
mA/cm². 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
15 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
20 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
25 coated with a thickness of 0.1 µm on the bonded
substrate, and only the silicon nitride film 136 on

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1 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
 5 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
 10 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%
 15 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 $1 \times 10^3/\text{cm}^2$ or less, whereby it could
 20 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,
 25 a high value of 2.1×10^{-3} sec. was exhibited.

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1 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/cm²). The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm². The porous structure formation rate at this time was 8.4 μ m/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 μ m 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



1 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
 5 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
 10 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
 15 current density at this time was 100 mA/cm^2 . The
 porous structure formation rate at this time was 8.4
 $\mu\text{m/min.}$ and the P-type (100) Si substrate having a
 thickness of 200 microns as a whole was made porous in
 24 minutes.

20 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°C

25 Pressure: 1×10^{-9} Torr

Growth rate: 0.1 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 °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 SiO₂. 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/cm². 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



1 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:

5 Gas: SiH_4
Radio frequency power: 100 W
Temperature: 800 °C
Pressure: 1×10^{-2} Torr
Growth rate: 2.5 nm/sec.

10 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,
15 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 a KOH solution of 6
M.

20 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
25 made porous having a thickness of 200 microns was
removed in 2 minutes.



1 Thus, a monocrystalline Si layer having good
crystallinity could be formed on the SiO₂.

Example 27

5 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/cm². The
porous structure formation rate at this time was 8.4
um/min. and the P-type (100) Si substrate having a
10 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:

15 RF frequency: 100 MHz
Radio frequency power: 600 w
Temperature: 300 °C
Ar gas pressure: 8×10^{-3} Torr
Growth time: 120 minutes
20 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
25 oxidized layer 44 of 5000 angstroms formed on the
surface was superposed on the above oxidized layer 45,



1 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-
5 nitric acid-acetic acid solution (1:3:6). 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
10 the SiO₂.

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
15 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
20 microscopy, the dislocation defect density was found
to be suppressed $1 \times 10^3/\text{cm}^2$ 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
25 time of minority carriers was measured for the
monocrystalline Si layer by use of the MOS C-t method,



1 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
 5 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 $8.4 \text{ } \mu\text{m/min.}$ and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in
 10 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
 15 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
 20 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
 25 porous Si substrate 41 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid

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1 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
5 layer could be formed on the SiO₂.

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
10 current density at this time was 100 mA/cm². 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
15 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: SiH₄
Carrier gas: H₂
20 Temperature: 650 °C
Pressure: 1 × 10⁻² Torr
Growth rate: 3.3 nm/sec.

Next, on the surface of the cpitaxial layer 42
was formed an oxidized layer 45 with a thickness of
25 1000 angstroms. Then, another Si substrate 43 having
an oxidized layer 44 of 5000 angstroms on the surface



1 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
5 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
10 layer 42 on SiO₂ could be formed. When SiH₂Cl₂ 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.

15 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
20 conditions are as follows:

Reactive gas flow rate: SiH₂Cl₂ 1000 SCCM

H₂ 230 l/min.

Temperature: 1080 °C

Pressure: 80 Torr

25 Time: 2 min.

The substrate was anodized in a 50% HF



1 solution. The current density at this time was 100
mA/cm². 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
5 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
10 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-
15 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 SiO₂ could be
20 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.

25 Example 31

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

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Reactive gas flow rate: SiH_2Cl_2 1000 SCCM
 H_2 230 l/min.
 Temperature: 1080 °C
 Pressure: 60 Torr
 Time: 1 min.

10 The substrate was anodized in a 50% HF
solution. The current density at this time was 100
mA/cm². 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
15 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

1 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-
5 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

10 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/cm²).
15 The substrate was anodized in a 50% HF solution. The
current density at this time was 100 mA/cm². 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
20 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.
25 Then, another Si substrate having an oxidized layer
145 of 5000 angstroms formed on the surface was

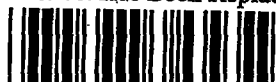


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1 closely contacted with the above oxidized layer 146,
and the two Si substrates were bonded together firmly
by heating at 700 °C for 0.5 hour. Subsequently, the
porous Si substrate was chemically etched away by use
5 of hydrofluoric acid-nitric acid-acetic 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
10 on SiO₂ 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
15 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
20 microscopy, the dislocation defect density was found
to be suppressed $1 \times 10^3/\text{cm}^2$ 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
25 time of minority carriers was measured for the
monocrystalline layer by use of the MOS C-t method, a



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1 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
5 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 $\mu\text{m/min.}$ and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in
10 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:

15 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
20 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 $\mu\text{m.}$ Subsequently, only the
25 nitride film 54 on the porous substrate 51 was removed by reactive ion etching. Then, the porous Si



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1 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
5 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
10 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
15 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
 $\mu\text{m/min}$. and the P-type (100) Si substrate having a
20 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:

25

Gas: SiH_4

Radio frequency power: 100 W

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1 Temperature: 800 °C
 Pressure: 1×10^{-2} Torr
 Growth rate: 2.5 nm/sec.

 Next, on the surface of the epitaxial layer 52
5 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
10 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,
15 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 8 μm on the low softening glass substrate
 53 could be obtained.

20 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/cm². The
25 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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1 thickness of 200 microns as a whole was made porous in
24 minutes. On the P-type (100) porous Si substrate
Si was grown an Si epitaxial layer to a thickness of
1.0 micron by the bias-sputtering method. The
5 deposition conditions are as follows:

RF frequency: 100 MHz

Radio frequency power: 600 W

Temperature: 300 °C

Ar gas pressure: 8×10^{-3} Torr

10 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
15 point around 500 °C applied with optical polishing,
and by heating in a nitrogen atmosphere at 450 °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
20 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
25 made porous having a thickness of 200 microns was
removed in 2 minutes. After removal of the Si_3N_4



1 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
5 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 $1 \times 10^3/\text{cm}^2$ 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

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

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1 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
 $\mu\text{m/min.}$ and the P-type (100) Si substrate having a
5 thickness of 200 microns as a whole was made porous in
24 minutes. On the P-type (100) porous Si substrate
Si was grown an Si epitaxial layer to a thickness of
10 microns by the liquid phase growth method. The
growth conditions are as follows:

10 Solvent: Sn
Growth temperature: 900°C
Growth atmosphere: H_2
Growth time: 20 minutes.

Next, on the surface of the epitaxial layer 52
15 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
20 coated on the bonded substrate with a thickness of 0.1
 $\mu\text{m.}$ 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
25 solution (1:3:8). As the result, the Si substrate 51
made porous having a thickness of 200 microns was



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1 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
5 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
10 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
 $\mu\text{m}/\text{min}$. and the P-type (100) Si substrate having a
15 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:

20 Source gas: SiH_4 800 SCCM
Carrier gas: H_2 150 l/min.
Temperature: 850 $^\circ\text{C}$
Pressure: 1×10^{-2} Torr
Growth rate: 3.3 nm/sec .

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

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1 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
5 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
10 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
15 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
20 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
25 of 1 micron by the CVD method. The deposition
conditions are as follows:

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Time: 2 min.

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5 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.

10 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:

20 The substrate was anodized in a 50% HF
solution. The current density at this time was 100
mA/cm². 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
25 made porous in 24 minutes. Only the P-type (100) Si
substrate was made porous in this anodization, and

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1 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 5 were bonded together firmly by heating at 800 °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 10 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. 15 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 20 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 25 300 microns was formed an N-type Si layer 152 with a thickness of 1 micron by ion implantation of protons.



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1 The amount of H⁺ implanted was 5×10^{15} (ions/cm²).
 The substrate was anodized in a 50% HF solution. The
 current density at this time was 100 mA/cm². The
 porous structure formation rate at this time was 8.4
 5 μ m/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
 10 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 °C for 0.5 hour in a nitrogen
 atmosphere. By the low pressure CVD method, Si₃N₄ was
 15 deposited to a thickness of 0.1 μ m to be coated on the
 bonded substrate. Subsequently, only 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-
 20 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 Si₃N₄ layer 155, a substrate having the
 monocrystalline Si layer 152 with a thickness of 1.0
 25 μ m on the fused silica 154 could be formed.

Also the thickness of the monocrystalline Si

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1 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
5 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
10 to be suppressed $1 \times 10^3/\text{cm}^2$ 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
15 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
20 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
25 invention, there can be provided a process for forming
a semiconductor substrate broad in scope of

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

Example 41

5 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
 $\mu\text{m/min.}$ and the P-type (100) Si substrate having a
10 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
15 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 62
20 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
25 hydrofluoric acid-nitric acid-acetic acid solution.
As the result, the Si substrate 61 made porous having

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1 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
5 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

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
15 $\mu\text{m}/\text{min}$. 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
20 conditions are as follows:

Gas: SiH_4

Radio frequency power: 100 W

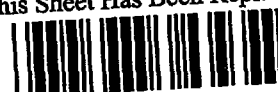
Temperature: 800 $^{\circ}\text{C}$

Pressure: 1×10^{-2} Torr

25 Growth rate: 2.5 nm/sec .

Next, on the surface of the epitaxial layer 62

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1 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
5 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
10 a thickness of 5 μ m 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
15 microns was anodized in a 50% HF solution. The
current density at this time was 100 mA/cm². The
porous structure formation rate at this time was 8.4
 μ m/min. and the P-type (100) Si substrate having a
thickness of 200 microns as a whole was made porous in
20 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
25 Radio frequency power: 600 W
Temperature: 300 °C

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1 Ar gas pressure: 8×10^{-3} Torr
Growth time: 120 minutes
Target direct current bias: - 200 V
Substrate direct current bias: + 5 V.

5 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
10 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
15 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
20 thickness of $1.0 \mu\text{m}$ 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
25 3 inches wafer, the difference between the maximum
value and the minimum value of the thickness of the

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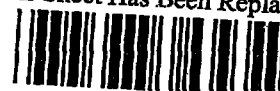
1 monocrystalline Si layer was found to be suppressed 5%
or less based on the maximum value of the thickness.
As the result of plan-view observation of the
monocrystalline Si layer by a transmission electron
5 microscopy, the dislocation defect density was found
to be suppressed $1 \times 10^3/\text{cm}^2$ 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
10 time of minority carriers was measured for the
monocrystalline layer by use of the MOS C-t method, a
high value of 2.1×10^{-3} sec. was exhibited.

Example 44-

A P-type (100) monocrystalline Si substrate
15 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 $100 \text{ mA}/\text{cm}^2$. The
porous structure formation rate at this time was 8.4
 $\mu\text{m}/\text{min.}$ and the P-type (100) Si substrate having a
20 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:

25 Solvent: Sn
Growth temperature: 900°C

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1 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 $800^\circ C$ applied with optical polishing, and by heating in a nitrogen atmosphere at $750^\circ C$ 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.

15 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 $\mu m/\text{min}$. 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:



Source gas: SiH_4 800 SCCM

Carrier gas: H_2 150 l/min.

Temperature: 850 °C

Pressure: 1×10^{-2} Torr

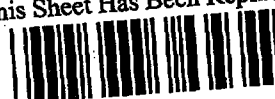
Growth rate: 3.3 nm/sec.

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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1 conditions are as follows:

Reactive gas flow rate: SiH_2Cl_2 1000 SCCM

H_2 230 l/min.

Temperature: 1080 °C

5 Pressure: 80 Torr

Time: 2 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm². The porous structure formation rate at this
10 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.

15 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
20 163 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
25 having a thickness of 1 μm on the fused silica glass substrate 164 could be formed.

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1 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
1.5 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
10 microscopy, the dislocation defect density was found
to be suppressed $1 \times 10^3/\text{cm}^2$ 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
15 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
20 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
25 H_2 230 l/min.
Temperature: 1080 °C



Pressure: 80 Torr

Time: 1 min.

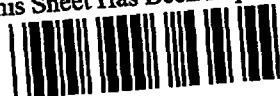
The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm². The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate 161 having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si 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 0.8 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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1 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.
 5 The amount of H^+ implanted was 5×10^{15} (ions/cm²).
 The substrate was anodized in a 50% HF solution. The
 current density at this time was 100 mA/cm². The
 porous structure formation rate at this time was 8.4
 um/min. and the P-type (100) Si substrate 161 having a
 10 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
 15 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
 20 (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
 25 observation by transmission electron microscopy, it
 was confirmed that no new crystal defect had been



1 introduced in the Si layer to maintain good
crystallinity.

Example 49

5 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
10 (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°C

15 Pressure: 50 Torr

Growth rate: $0.1 \mu\text{m/min}$.

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

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



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1 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
5 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
10 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
15 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
20 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
25 Si_3N_4 , and only the Si layer made porous could be
completely removed.



1 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
5 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
10 microscopy, the dislocation defect density was found
to be suppressed $1 \times 10^3/\text{cm}^2$ 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
15 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:

20 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
25 the surface of the non-porous monocrystalline
semiconductor region, and then

 removing the porous monocrystalline
semiconductor region by etching.





1 WHAT IS CLAIMED IS:

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

forming a member having a non-porous
5 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
10 semiconductor region, and then

removing said porous monocrystalline semiconductor region by etching.

2. A process for preparing a semiconductor
15 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
20 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
25 of 50 microns or less.





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

5 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.

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

15 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.

20

 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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1 region porous by anodization.

10. A process for preparing a semiconductor
member according to Claim 9, wherein said anodization
5 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-
10 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
15 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
20 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
25 substance is a silicon substrate with its surface
being oxidized.





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1 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
5 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.

10

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

15 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,

20 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
25 the surface of the region constituted of said
insulating substance, and

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1 removing said porous monocrystalline
semiconductor region by etching.

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

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

15 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.

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

25 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.

5

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.

10

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.

15

20

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

25

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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1 N-type.

29. A process for preparing a semiconductor member according to Claim 28, wherein said N-type
3 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
10 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
15 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
20 porous monocrystalline semiconductor region is carried out under the state where the members bonded to each other are covered with an anti-etching material.

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

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1 etching material is silicon nitride.

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

35. A process for preparing a semiconductor member comprising the steps of:
making a non-porous monocrystalline
10 semiconductor member porous to form a porous monocrystalline semiconductor region,

forming a non-porous monocrystalline semiconductor region on said porous monocrystalline semiconductor region,
15 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
20 semiconductor region by etching.

36. A process for preparing a semiconductor member according to Claim 35, wherein said monocrystalline semiconductor comprises silicon.
25

37. A process for preparing a semiconductor

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

5 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.

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

15 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.

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

25 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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1 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.

5

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

10

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

15

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

20

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

25

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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1 substance comprises a light-transmissive material.

48. A process for preparing a semiconductor
member according to Claim 36, wherein the member of
5 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
10 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
15 semiconductor region on said porous monocrystalline
semiconductor region,

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

20 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
25 semiconductor region by etching.

50. A process for preparing a semiconductor





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

51. A process for preparing a semiconductor
5 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
10 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
15 step is carried out in an atmosphere containing
nitrogen.

54. A process for preparing a semiconductor
member according to Claim 49, wherein said bonding
20 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
25 monocrystalline semiconductor region is formed by
epitaxial growth.

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1 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
5 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
10 member according to Claim 49, wherein said porous
monocrystalline semiconductor region is obtained by
anodization.

 58. A process for preparing a semiconductor
15 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
20 monocrystalline semiconductor region is intrinsic or N-
type.

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

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1 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.

5

 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
10 being oxidized.

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

 making a first non-porous monocrystalline
15 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
20 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

25 removing said second non-porous

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

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

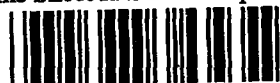
65. A process for preparing a semiconductor
10 member according to Claim 63, wherein said porous
monocrystalline semiconductor region is P-type.

66. A process for preparing a semiconductor
member according to Claim 63, wherein said third non-
15 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
20 step is carried out in an atmosphere containing
nitrogen.

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

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1 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.

5 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
10 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.

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

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

25 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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1 intrinsic or N-type.

74. A process for preparing a semiconductor member according to Claim 73, wherein said N-type
5 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
10 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
15 substance is a silicon substrate with its surface being oxidized.

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

20 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
25 semiconductor region on said porous monocrystalline





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- 1 semiconductor region,
forming a region constituted of an insulating
substance on said third non-porous monocrystalline
semiconductor region side,
5 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
10 monocrystalline semiconductor by mechanical polishing,
and removing said porous monocrystalline semiconductor
region by etching.

78. A process for preparing a semiconductor
15 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
20 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
25 thickness of 50 microns or less.

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

5

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.

10

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.

15

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.

20

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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1 anodization.

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

87. A process for preparing a semiconductor member according to Claim 70, wherein said third non-porous monocrystalline semiconductor region is
10 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.
15

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.
20

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
25 being oxidized.





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

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

10 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 crystalline semiconductor region, and

15 removing said porous monocrystalline semiconductor region by etching.

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

93. A process for preparing a semiconductor member according to Claim 91, wherein said first
25 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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1 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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1 99. A process for preparing a semiconductor member according to Claim 98, wherein said anodization is carried out in an HF solution.

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

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

15 102. 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.

20 103. 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.

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

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

5 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
10 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

15 removing said porous monocrystalline
semiconductor region by etching.

 105. A process for preparing a semiconductor
member according to Claim 104, wherein said
20 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.

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





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

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

109. A process for preparing a semiconductor
10 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
15 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
20 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
25 phase growth method or the bias-sputtering method.





- 1 112. A process for preparing a semiconductor member according to Claim 104, wherein said porous monocrystalline semiconductor region is obtained by anodization.
- 5 113. A process for preparing a semiconductor member according to Claim 112, wherein said anodization is carried out in an HF solution.
- 10 114. A process for preparing a semiconductor member according to Claim 105, wherein said second non-porous monocrystalline semiconductor region is intrinsic or N-type.
- 15 115. A process for preparing a semiconductor member according to Claim 114, wherein said N-type silicon is formed by proton irradiation or epitaxial growth.
- 20 116. 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.
- 25 117. A process for preparing a semiconductor member according to Claim 104, wherein the member of





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

5 11A. 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
10 constituted of an insulating substance bonded onto the
 surface of said non-porous monocrystalline
 semiconductor region.

 119. A semiconductor member according to Claim
15 118, wherein said monocrystalline semiconductor
 comprises silicon.

 120. A semiconductor member according to Claim
 118, wherein said porous monocrystalline semiconductor
20 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
25 less.

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1 122. A semiconductor member comprising:
a first member having a non-porous
monocrystalline semiconductor region and a region
constituted of an insulating substance arranged in
5 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
10 substance.

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

15
124. A semiconductor member according to Claim
122, wherein said porous monocrystalline semiconductor
region is P-type.

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

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





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1 on a region constituted of an insulating substance,
characterized in that the dislocation defect density
in said non-porous silicon monocrystalline
semiconductor region is $2.0 \times 10^4/\text{cm}^2$ or less, and the
5 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,
10 characterized in that the dislocation defect density
in said non-porous silicon monocrystalline
semiconductor region is $2.0 \times 10^4/\text{cm}^2$ 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
15 minimum value of the thickness of said silicon
monocrystalline semiconductor region is 10% or less
based on said maximum value.

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