As a result, a laser beam having a plurality of peak groups occur. When a plurality of pulsed laser beams outputted from such a pulsed laser light source are used, a difference in peak shape may produce a different result due to laser beam irradiation even if an object is irradiated with the pulsed laser beams at the same energy density.

[0006]

Note that a prior art laser irradiation apparatus is generally configured to use an energy monitor to control the output of laser beams, and hence can operate by maintaining the same energy density of the laser beams. However, even if the pulsed laser light source maintains a constant energy density, a change in peak shape occurs over time by a change in gas mixing ratio or the like. For this reason, there is a problem in that when an amorphous semiconductor is crystallized by irradiation with laser beams, a change in crystallization action occurs, and hence it is difficult to obtain the equivalent crystals with good quality.

[0007]

In view of the above circumstances, the present invention has been made, and embodiments of the present invention are to provide a crystalline semiconductor manufacturing method and a crystalline semiconductor manufacturing apparatus capable of more uniformly crystallizing an amorphous semiconductor.

According to a first aspect of the invention, a crystalline semiconductor manufacturing method of crystallizing an amorphous semiconductor by irradiating the amorphous semiconductor with a plurality of pulsed laser beams guided through different paths is provided, wherein the plurality of pulsed laser beams are emitted onto the

amorphous semiconductor at the same energy density include, in one pulse in a temporal intensity change, at least a first peak group appearing and a second peak group later appearing, and a maximum peak intensity of the first peak group is a maximum height in the one pulse, and

assuming that a maximum peak intensity ratio is defined as a ratio b/a between the maximum peak intensity a of the first peak group and the maximum peak intensity b of the second peak group, and the maximum peak intensity ratio serving as a previously determined reference is defined as a reference maximum peak intensity ratio, the maximum peak intensity ratio of the plurality of pulsed laser beams is set to have a difference of less than or equal to 4% with respect to the reference maximum peak intensity ratio and the plurality of pulsed laser beams are set such that between any of each pulsed laser beam, assuming that a maximum peak intensity ratio of one of the pulsed laser beams is defined as a reference maximum peak intensity ratio, the maximum peak intensity ratio of the other of the pulsed laser beams has a difference of less than or equal to 4% with respect to the reference maximum peak intensity ratio.

According to a second aspect of the invention, a crystalline semiconductor manufacturing apparatus is provided. The apparatus comprises

one or two or more laser light sources; and

an optical system guiding a plurality of pulsed laser beams to an amorphous semiconductor, the plurality of pulsed laser beams being outputted from the laser light sources, the plurality of pulsed laser beams are emitted onto the amorphous semiconductor at the same energy density and including, in one pulse in a temporal intensity change, at

least a first peak group appearing and a second peak group later appearing, a maximum peak intensity of the first peak group being a maximum height in the one pulse, and the plurality of pulsed laser beams being guided through different paths, wherein

the plurality of pulsed laser beams are set for each pulsed laser beam such that assuming that a maximum peak intensity ratio is defined as a ratio b/a between the maximum peak intensity a of the first peak group and the maximum peak intensity b of the second peak group, and the maximum peak intensity ratio serving as a previously determined reference is defined as a reference maximum peak intensity ratio, the maximum peak intensity ratio is set to have a difference of less than or equal to 4% with respect to the reference maximum peak intensity ratio and the plurality of pulsed laser beams are set such that between any of each pulsed laser beam, assuming that a maximum peak intensity ratio of one of the pulsed laser beams is defined as a reference maximum peak intensity ratio, the maximum peak intensity ratio of the other of the pulsed laser beams has a difference of less than or equal to 4% with respect to the reference maximum peak intensity ratio.

Solution to Problem

[0008]

Specifically, a first aspect of the present invention according to a crystalline semiconductor manufacturing method

Claims

[Claim 1]

A crystalline semiconductor manufacturing method of crystallizing an amorphous semiconductor by irradiating the amorphous semiconductor with a plurality of pulsed laser beams guided through different paths, wherein

the plurality of pulsed laser beams are emitted onto the amorphous semiconductor at the same energy density, include, in one pulse in a temporal intensity change, at least a first peak group appearing and a second peak group later appearing, and a maximum peak intensity of the first peak group is a maximum height in the one pulse, and

assuming that a maximum peak intensity ratio is defined as a ratio b/a between the maximum peak intensity a of the first peak group and the maximum peak intensity b of the second peak group, and the maximum peak intensity ratio serving as a previously determined reference is defined as a reference maximum peak intensity ratio, the maximum peak intensity ratio of the plurality of pulsed laser beams is set to have a difference of less than or equal to 4% with respect to the reference maximum peak intensity ratio, and

the plurality of pulsed laser beams are set such that between any of each pulsed laser beam, assuming that a maximum peak intensity ratio of one of the pulsed laser beams is defined as a reference maximum peak intensity ratio, the maximum peak intensity ratio of the other of the pulsed laser beams has a difference of less than or equal to 4% with respect to the reference maximum peak intensity ratio.

[Claim 2]

The crystalline semiconductor manufacturing method according to claim 1, wherein the plurality of pulsed laser beams are emitted onto the amorphous semiconductor at mutually different pulse generation timings.

[Claim 3]

The crystalline semiconductor manufacturing method according to claim 1 or 2, wherein the plurality of pulsed

laser beams are outputted from a plurality of laser light sources.

~~[Claim 4]~~

~~The crystalline semiconductor manufacturing method according to any one of claims 1 to 3, wherein the plurality of pulsed laser beams are emitted onto the amorphous semiconductor at the same energy density.~~

[Claim 45]

The crystalline semiconductor manufacturing method according to any one of claims 1 to 34, wherein the maximum peak intensity ratio of the plurality of pulsed laser beams are within a preset predetermined range.

~~[Claim 6]~~

~~The crystalline semiconductor manufacturing method according to any one of claims 1 to 5, wherein the reference maximum peak intensity ratio is a maximum peak intensity ratio of one pulsed laser beam of the plurality of pulsed laser beams.~~

~~[Claim 7]~~

~~The crystalline semiconductor manufacturing method according to any one of claims 1 to 6, wherein the plurality of pulsed laser beams are set such that between any of each pulsed laser beam, assuming that a maximum peak intensity ratio of one of the pulsed laser beams is defined as a reference maximum peak intensity ratio, the maximum peak intensity ratio of the other of the pulsed laser beams has a~~

~~difference of less than or equal to 4% with respect to the reference maximum peak intensity ratio.~~

[Claim 58]

The crystalline semiconductor manufacturing method according to any one of claims 1 to ~~4~~7, wherein the amorphous semiconductor is an amorphous silicon thin film formed on a substrate.

[Claim ~~6~~9]

A crystalline semiconductor manufacturing apparatus comprising:

one or two or more laser light sources; and

an optical system guiding a plurality of pulsed laser beams to an amorphous semiconductor, the plurality of pulsed laser beams being outputted from the laser light sources, the plurality of pulsed laser beams are emitted onto the amorphous semiconductor at the same energy density, including, in one pulse in a temporal intensity change, at least a first peak group appearing and a second peak group later appearing, a maximum peak intensity of the first peak group being a maximum height in the one pulse, and the plurality of pulsed laser beams being guided through different paths, wherein

the plurality of pulsed laser beams are set for each pulsed laser beam such that assuming that a maximum peak intensity ratio is defined as a ratio b/a between the maximum peak intensity a of the first peak group and the maximum peak intensity b of the second peak group, and the maximum peak intensity ratio serving as a previously determined reference is defined as a reference maximum peak intensity ratio, the maximum peak intensity ratio is set to have a difference of less than or equal to 4% with respect to the reference maximum peak intensity ratio, and

the plurality of pulsed laser beams are set such that between any of each pulsed laser beam, assuming that a maximum peak intensity ratio of one of the pulsed laser beams is defined as a reference maximum peak intensity ratio, the maximum peak intensity ratio of the other of the pulsed laser beams has a difference of less than or equal to 4% with respect to the reference maximum peak intensity ratio.

[Claim 7~~10~~]

The crystalline semiconductor manufacturing apparatus according to claim 6~~9~~, wherein the plurality of pulsed laser

beams are emitted onto the amorphous semiconductor at different pulse generation timings.

[Claim 8~~11~~]

The crystalline semiconductor manufacturing apparatus according to claim 6~~9~~ or 7~~10~~, wherein the different pulse generation timings are given by the laser light sources and/or the optical system.

[Claim 9~~12~~]

The crystalline semiconductor manufacturing apparatus according to any one of claims 6~~9~~ to 8~~11~~, comprising a peak intensity ratio adjusting unit adjusting the maximum peak intensity ratio outputted from the laser light sources.

[Claim 10~~13~~]

The crystalline semiconductor manufacturing apparatus according to any one of claims 6~~9~~ to 9~~12~~, comprising an energy density setting unit setting the energy density for emitting the plurality of pulsed laser beams onto the amorphous semiconductor at the same energy density.

[Claim 11~~14~~]

A ~~laser annealing apparatus~~ crystalline semiconductor manufacturing apparatus according to any one of claims 6~~9~~ to 10~~13~~, comprising a scanning apparatus relatively scanning and emitting the plurality of pulsed laser beams to the amorphous semiconductor.