

determine the number of times of irradiation with the laser.

[0005]

In an intensity distribution of a beam cross section of a pulsed laser, there is an area at a scanning direction end section in which the intensity gradually decreases to 0. Patent Literature 1 addresses an issue that in the overlap irradiation of the pulsed laser with the intensity distribution, there is a difference in mobility when transistors are formed in irradiation areas irradiated for a plurality of times with different intensity areas (paragraphs 0015 to 0019). To solve the problem, proposed is a method of setting the scanning pitch equal to or smaller than a predetermined value according to the intensity area. Patent Literature 1 states that the method allows manufacturing thin-film transistors with significantly small variations in mobility (paragraph 0026).

#### Citation List

##### Patent Literature

[0006]

Patent Literature 1: Japanese Patent Laid-Open No. 9-45926

#### Summary of Invention

According to the first aspect of the invention, a laser processing method of forming a crystal semiconductor film by performing overlap irradiation at a predetermined scanning pitch while scanning a non-single crystal semiconductor film by a pulsed laser with a predetermined beam cross section profile is provided, wherein

the overlap irradiation of the pulsed laser is performed by setting the scanning pitch in a range satisfying the following Formula (1), wherein

b denotes a length in a scanning direction of a base of a rising section formed by the irradiation of the semiconductor film with the pulsed laser, formed on a back end side in the scanning direction of a pulsed laser beam directed to the semiconductor film, and p denotes the scanning pitch.

$$0.75b \geq p \geq 0.25b \quad \dots (1)$$

According to the second aspect of the invention, A laser processing apparatus comprising:

a pulse oscillation laser light source that outputs a pulsed laser at a predetermined repetition frequency;

an optical system that adjusts a beam cross section profile of the pulsed laser and guides the pulsed laser to a non-single crystal semiconductor film;

an attenuator that adjusts an energy density of the pulsed laser;

a scanning apparatus that relatively scans the non-single crystal semiconductor film with the pulsed laser at a predetermined scanning speed; and

a control unit that controls the laser light source, the attenuator, and the scanning apparatus, wherein

the control unit acquires a length b in a scanning direction of a base of a rising section formed by irradiation of a semiconductor film with the pulsed laser, formed on a back end side in the scanning direction of a pulsed laser beam directed to the semiconductor film, and determines the repetition frequency in the laser light source and the scanning speed of the scanning apparatus according to the length in the scanning direction so that a scanning pitch p at the irradiation of the non-single crystal semiconductor film with the pulsed laser satisfies the following Formula (1).

$$0.75b \geq p \geq 0.25b \quad \dots (1)$$

Technical Problem

## Claims

## [Claim 1]

A laser processing method of forming a crystal semiconductor film by performing overlap irradiation at a predetermined scanning pitch while scanning a non-single crystal semiconductor film by a pulsed laser with a predetermined beam cross section profile, wherein

the overlap irradiation of the pulsed laser is performed by setting the scanning pitch in a range satisfying the following Formula (1), wherein

b denotes a length in a scanning direction of a base of a rising section formed by the irradiation of the semiconductor film with the pulsed laser, formed on a back end side in the scanning direction of a pulsed laser beam directed to the semiconductor film, and p denotes the scanning pitch.

$$0.75b \geq p \geq 0.25b \quad \dots (1)$$

## [Claim 2]

The laser processing method according to claim 1, wherein

the irradiation of the semiconductor film with the pulsed laser is performed at an irradiation energy density optimal for crystallization on the semiconductor film.

## [Claim 3]

The laser processing method according to claim 1 or 2, wherein

a wavelength of the pulsed laser is 400 nm or less.

[Claim 4]

The laser processing method according to any of claims 1 to 3, wherein

a pulse half value width of the pulsed laser is 200 ns or less.

[Claim 5]

The laser processing method according to any of claims 1 to 4, wherein

the non-single crystal semiconductor is silicon.

[Claim 6]

The laser processing method according to any of claims 1 to 5, wherein

the scanning pitch is 5 to 20  $\mu\text{m}$ .

[Claim 7]

The laser processing method according to any of claims 1 to 6, wherein

the length in the scanning direction of the base of the rising section formed on the back end side in the scanning direction of the pulsed laser beam directed to the semiconductor film by the irradiation of the semiconductor film with the pulsed laser is measured , and the scanning pitch is determined based on a result of the measurement.

[Claim 8]

A laser processing apparatus comprising:

a pulse oscillation laser light source that outputs a pulsed laser at a predetermined repetition frequency;

an optical system that adjusts a beam cross section profile of the pulsed laser and guides the pulsed laser to a non-single crystal semiconductor film;

an attenuator that adjusts an energy density of the pulsed laser;

a scanning apparatus that relatively scans the non-single crystal semiconductor film with the pulsed laser at a predetermined scanning speed; and

a control unit that controls the laser light source, the attenuator, and the scanning apparatus, wherein

the control unit acquires a length  $b$  in a scanning direction of a base of a rising section formed by irradiation of a semiconductor film with the pulsed laser, formed on a back end side in the scanning direction of a pulsed laser beam directed to the semiconductor film, and determines the repetition frequency in the laser light source and the scanning speed of the scanning apparatus according to the length in the scanning direction so that a scanning pitch  $p$  at the irradiation of the non-single crystal semiconductor film with the pulsed laser satisfies the following Formula (1).

$$0.75b \geq p \geq 0.25b \quad \dots (1)$$

[Claim 9]

The laser processing apparatus according to claim 8,  
further comprising

a film surface profile measurement apparatus that  
measures the length  $b$  in the scanning direction of the  
base of the rising section formed by the irradiation of  
the semiconductor film with the pulsed laser, formed on  
the back end side in the scanning direction of the pulsed  
laser beam directed to the semiconductor film.

[Claim 1]

A laser processing method of forming a crystal semiconductor film by performing overlap irradiation at a predetermined scanning pitch while scanning a non-single crystal semiconductor film by a pulsed laser with a predetermined beam cross section profile, wherein

the overlap irradiation of the pulsed laser is performed by setting the scanning pitch in a range satisfying the following Formula (1), wherein

b denotes a length in a scanning direction of a base of a rising section formed by the irradiation of the semiconductor film with the pulsed laser, formed on a back end side in the scanning direction of a pulsed laser beam directed to the semiconductor film, and p denotes the scanning pitch.

$$0.75b \geq p \geq 0.25b \quad \dots (1)$$

[Claim 2]

The laser processing method according to claim 1, wherein

the irradiation of the semiconductor film with the pulsed laser is performed at an irradiation energy density optimal for crystallization on the semiconductor film.

[Claim 3]

The laser processing method according to claim 1 or 2, wherein a wavelength of the pulsed laser is 400 nm or less.

[Claim 4]

The laser processing method according to any of claims 1 to 3,  
wherein

a pulse half value width of the pulsed laser is 200 ns or less.

[Claim 5]

The laser processing method according to any of claims 1 to 4,  
wherein

the non-single crystal semiconductor is silicon.

[Claim 6]

The laser processing method according to any of claims 1 to 5,  
wherein

the scanning pitch is 5 to 20  $\mu$ m.

[Claim 7]

The laser processing method according to any of claims 1 to 6,  
wherein

the length in the scanning direction of the base of the rising section formed on the back end side in the scanning direction of the pulsed laser beam directed to the semiconductor film by the irradiation of the semiconductor film with the pulsed laser is measured, and the scanning pitch is determined based on a result of the measurement.

[Claim 8]

A laser processing apparatus comprising:

a pulse oscillation laser light source that outputs a pulsed laser at a predetermined repetition frequency;

an optical system that adjusts a beam cross section profile of the pulsed laser and guides the pulsed laser to a non-single crystal semiconductor film;

an attenuator that adjusts an energy density of the pulsed laser;

a scanning apparatus that relatively scans the non-single crystal semiconductor film with the pulsed laser at a predetermined scanning speed; and

a control unit that controls the laser light source, the attenuator, and the scanning apparatus, wherein

the control unit acquires a length  $b$  in a scanning direction of a base of a rising section formed by irradiation of a semiconductor film with the pulsed laser, formed on a back end side in the scanning direction of a pulsed laser beam directed to the semiconductor film, and determines the repetition frequency in the laser light source and the scanning speed of the scanning apparatus according to the length in the scanning direction so that a scanning pitch  $p$  at the irradiation of the non-single crystal semiconductor film with the pulsed laser satisfies the following Formula (1).

$$0.75b \geq p \geq 0.25b \quad \dots (1)$$

[Claim 9]

The laser processing apparatus according to claim 8, further comprising

a film surface profile measurement apparatus that measures the length  $b$  in the scanning direction of the base of the rising section formed by the irradiation of the semiconductor film with

the pulsed laser, formed on the back end side in the scanning direction of the pulsed laser beam directed to the semiconductor film.