

Citation List

Patent Literature

[0007]

Patent Literature 1: Japanese Patent Laid-Open No. 5-206558

Patent Literature 2: Japanese Patent Laid-Open No. 9-321310

Summary of Invention

[0007a] According to the first aspect of the invention, there is provided a laser annealing method comprising irradiating a non-single-crystal semiconductor film with a pulsed laser beam having a linear beam cross-sectional shape while scanning the non-single-crystal semiconductor film with the linear beam in a minor-axis direction of the linear beam, wherein

the linear beam has, in the minor-axis direction, a flat portion and steepness portions in a beam intensity profile, the steepness portions located in minor-axis-direction end portions ~~in a beam intensity profile,~~ and the steepness portions are areas having intensities greater than or equal to 10% but smaller than or equal to 90% of a maximum intensity in the beam intensity profile, and

the flat portion has a minor-axis-direction width of an area having intensities at least 96% of the maximum intensity, and the minor-axis-direction width ranges from 100 to 500 μ m on the irradiation surface of the non-single-crystal semiconductor film, and a screening irradiation ~~is performed~~ in an area outward from a position where the intensity is from 70 to 90% of the maximum intensity at a rear side in a minor-

axis scanning direction of the flat portion such that a minor-axis-direction width of the steepness portion which is one of the steepness portions and which is located on the rear side in the scan direction is 50 μm or smaller on an irradiation surface of the non-single-crystal semiconductor film.

[0007b] According to the second aspect of the invention, there is a laser annealing apparatus comprising:

~~a laser light source that outputs a pulsed laser beam;~~
~~an attenuator that adjusts transmittance at which the attenuator transmits the pulsed laser beam; and~~
~~an optical system that shapes the beam cross sectional shape of the pulsed laser beam and guides the shaped pulsed laser beam to an irradiation surface of a non single-crystal semiconductor film, wherein~~

~~the optical system includes an optical member that shapes the beam cross sectional shape of the pulsed laser beam to a linear beam having a high intensity area where the intensity is higher than or equal to a predetermined intensity in a beam intensity profile and an optical member that steepens at least a steepness portion which is one of steepness portions located in minor-axis direction end portions of the linear beam and which is the steepness portion on the rear side in a scan direction in such a way that a minor-axis direction width of the steepness portion is 50 μm or smaller on the irradiation surface of the non-single-crystal semiconductor film.~~
a laser light source that outputs a pulsed laser beam;

an attenuator that adjusts transmittance at which the attenuator transmits the pulsed laser beam; and

an optical system that shapes the beam cross-sectional shape of the pulsed laser beam and guides the shaped pulsed laser beam to an irradiation surface of a non-single-crystal semiconductor film, wherein

the optical system includes an optical member and a screener, and

the optical member shapes the beam cross-sectional shape of the pulsed laser beam to a linear beam, the linear beam having a high intensity area where the intensity is higher than or equal to a predetermined intensity in a beam intensity profile, the linear beam having, in the minor-axis direction, a flat portion and steepness portions in a beam intensity profile, the steepness portions located in minor-axis-direction end portions and being areas having intensities greater than or equal to 10% but smaller than or equal to 90% of a maximum intensity in the beam intensity profile, the flat portion having a minor-axis-direction width of an area having intensities at least 96% of the maximum intensity, the minor-axis-direction width ranging from 100 to 500 μm on the irradiation surface of the non-single-crystal semiconductor film, and

the screener is disposed in an optical path of the pulsed laser beam and screens a beam cross section of the pulsed laser beam in an area outward from a position where the intensity is from 70 to 90% of the maximum intensity at a rear side in the minor-axis scanning direction of the flat portion in such a way that a minor-axis-direction width of at least a steepness portion which is one of steepness portions located

in minor-axis-direction end portions of the linear beam and
which is the steepness portion on the rear side in a scan
direction is 50 μm or smaller on the irradiation surface of
the non-single-crystal semiconductor film.

Technical Problem

[0008]

It is, however, difficult to completely eliminate the steepness portions even by using a mask, a slit, or a variety of optical systems. The steepness portions can be suppressed, for example, through optical member design, but an attempt of excessive suppression of the steepness portions, for example, through optical member design undesirably results in local formation of intensity impulses 151a, where the intensity steeply increases, at the minor-axis ends of a flat portion 151 in the beam intensity profile of a pulsed laser beam 150, as shown in Figure 8. On the other hand, when a mask or a slit is used, a diffraction phenomenon undesirably similarly causes formation of the intensity impulses 151a, where the intensity steeply increases, at the minor-axis ends of the flat portion 151 in the beam intensity profile of

Claims

[Claim 1]

A laser annealing method comprising irradiating a non-single-crystal semiconductor film with a pulsed laser beam having a linear beam cross-sectional shape while scanning the non-single-crystal semiconductor film with the linear beam in a minor-axis direction of the linear beam, wherein

the linear beam has, in the minor-axis direction, a flat portion and steepness portions in a beam intensity profile, the steepness portions located in minor-axis-direction end portions in a beam intensity profile, and the steepness portions are areas having intensities greater than or equal to 10% but smaller than or equal to 90% of a maximum intensity in the beam intensity profile, and the flat portion has a minor-axis-direction width of an area having intensities at least 96% of the maximum intensity, and the minor-axis-direction width ranges from 100 to 500 μm on the irradiation surface of the non-single-crystal semiconductor film, and

a screening the irradiation is performed in an area outward from a position where the intensity is from 70 to 90% of the maximum intensity at a rear side in a minor-axis scanning direction of the flat portion such that a minor-axis-direction width of the steepness portion which is one of the steepness portions and which is located on the rear side in the scan direction is 50 μm or smaller on an irradiation surface of the non-single-crystal semiconductor film.

[Claim 2]

The laser annealing method according to claim 1, wherein the pulsed laser beam has a wavelength of 400 nm or shorter.

[Claim 3]

The laser annealing method according to claim 1 or 2, wherein a pulse of the pulsed laser beam on the irradiation surface has a full width at half maximum of 200 ns or smaller.

[Claim 4]

The laser annealing method according to any of claims 1 to 3, wherein the pulsed laser beam has a maximum intensity ranging from 250 to 500 mJ/cm² in the beam intensity profile on the irradiation surface.

[Claim 5]

The laser annealing method according to any of claims 1 to 4, wherein the non-single-crystal semiconductor is silicon.

[Claim 6]

The laser annealing method according to any of claims 1 to 5, wherein ~~the beam intensity profile of the pulsed laser beam has a flat portion in the minor-axis direction, and~~ the maximum intensity is defined as an average of the intensities across the flat portion.

[Claim 7]

The laser annealing method according to any of claims 1 to 6, wherein when the beam intensity profile of the pulsed laser beam has an intensity impulse where the intensity locally increases at one of the ends or at both ends of the beam intensity profile, the maximum intensity is defined as a value within a range excluding the intensity impulse.

[Claim 8]

~~The laser annealing method according to claim 6 or 7, wherein the linear beam has a minor-axis-direction width of an area having intensities at least 96% of the maximum intensity, and the minor-axis-direction width ranges from 100 to 500 μm on the irradiation surface of the non-single-crystal semiconductor film.~~

[Claim 8_9]

A laser annealing apparatus comprising:

a laser light source that outputs a pulsed laser beam;

an attenuator that adjusts transmittance at which the attenuator transmits the pulsed laser beam; and

an optical system that shapes the beam cross-sectional shape of the pulsed laser beam and guides the shaped pulsed laser beam to an irradiation surface of a non-single-crystal semiconductor film, wherein

the optical system includes an optical member and a screener, and

the optical member that shapes the beam cross-sectional shape of the pulsed laser beam to a linear beam, the linear beam having a high intensity area where the intensity is higher than or equal to a predetermined intensity in a beam intensity profile, the linear beam having, in the minor-axis direction, a flat portion and steepness portions in a beam intensity profile, the steepness portions located in minor-axis-direction end portions and being areas having intensities greater than or equal to 10% but smaller than or equal to 90% of a maximum intensity in the beam intensity profile, the flat portion having a minor-axis-direction width of an area having intensities at least 96% of the maximum intensity, the minor-axis-direction width ranging from 100 to 500 μm on the irradiation surface of the non-single-crystal semiconductor film, and

the screener an optical member that steepens is disposed in an optical path of the pulsed laser beam and screens a beam cross section of the pulsed laser beam in an area outward from a position where the intensity is from 70 to 90% of the maximum intensity at a rear side in the minor-axis scanning direction of the flat portion at least a steepness portion which is one of steepness portions located in minor-axis-direction end portions of the linear beam and which is the steepness portion on the rear side in a scan direction in such a way that a minor-axis-direction width

of at least a the steepness portion which is one of steepness portions located in minor-axis-direction end portions of the linear beam and which is the steepness portion on the rear side in a scan direction is 50 μ m or smaller on the irradiation surface of the non-single-crystal semiconductor film.

~~[Claim 10]~~

~~———— The laser annealing apparatus according to claim 9, wherein the optical member that steepens the steepness portion is a screener that is disposed in an optical path of the pulsed laser beam and screens part of a beam cross section of the pulsed laser beam.~~

~~[Claim 11]~~

~~———— The laser annealing apparatus according to claim 10, wherein the screener screens part of the beam cross section of the pulsed laser beam in areas outside the minor-axis-direction ends of the high intensity area.~~

~~[Claim 9-12]~~

The laser annealing apparatus according to any of claims 8-9 to 11, wherein the pulsed laser beam outputted from the laser light source has a wavelength of 400 nm or shorter.

~~[Claim 10-13]~~

The laser annealing apparatus according to any of claims 8 or 9-9 to 12, wherein the pulsed laser beam outputted from the laser light source has a full width at half maximum of 200 ns or smaller.

~~[Claim 14]~~

~~———— The laser annealing apparatus according to any of claims 9 to 13, wherein the optical system includes an~~

~~optical member that adjusts the intensity in such a way that a beam intensity profile having the high intensity area where the intensity is at least 96% of a maximum intensity and steepness portions located in end portions of the high intensity area is provided.~~

[Claim ~~11~~ 15]

The laser annealing apparatus according to any of claims ~~8 to 10~~ 9 to 14, wherein the attenuator adjusts the maximum intensity in the beam intensity profile of the pulsed laser beam on the irradiation surface of the non-single-crystal semiconductor film to a value ranging from 250 to 500 mJ/cm².