Laser irradiating apparatus

Field of the Invention

The present invention relates to a laser irradiating apparatus and more particularly to a laser irradiating apparatus which is capable of easily controlling the location and movement at a high speed along the major axis of its band-like irradiation area.

Background of the Invention

A method of manufacturing semiconductor devices is known where a light beam forming a band-like irradiation area is focused onto a substrate to be processed through being moved for scanning along the minor axis of the band-like irradiation area and shifted along the major axis of the band-lie irradiation area (See Patent Citation 1, for example).

Patent Citation 1: JP Patent Laid-open Publication No. (Heisei)04-10216.

Disclosure of the Invention

(Problems that the Invention is to solve)

In such a prior art, a carbon heater or an XY stage on which the substrate to be processed is placed is moved for shifting the band-like irradiation area along the major axis.

However, since the carbon heater or the XY stage is large in the mass, its movement will be low in the response

and highly difficult for being position controlled at high speeds.

It is hence an object of the present invention to provide a laser irradiating apparatus which is capable of easily controlling the location and movement at a high speed along the major axis of its band-like irradiation area.

(Means for solving the Problems)

According to a first aspect of the present invention, a laser irradiating apparatus (100) is provided comprising: a laser oscillator (1) for emitting a pulsed form of laser beam (B1); a reflector (2) for reflecting the laser beam (B1); an optical system (3) for shaping the reflection (B2) of the laser beam (B1) to form a band-like irradiation area (4) of which the major axis extends in a direction where the reflected laser beam (B2) is shifted by a change in the location or the angle (θ) of the reflection surface (2b) of the reflector (2), on which the laser beam (B1) falls, in relation to the laser beam (B1) and projecting the band-like irradiation area (4) of the reflected laser beam (B2) on a semiconductor substrate (S); a movable table (5) for holding and moving the semiconductor substrate (S) along the minor axis of the band-like irradiation area (4); a reflector driving means (6) for changing the location or the angle of the reflector (2); and a timing controlling means (8) for controlling the timing for changing the

location or the angle of the reflector (2) with the reflector driving means (6) as well as the timing for emitting the pulsed form of the laser beam (B1) from the laser oscillator (1) in order to shift the band-like irradiation area within a given area along the major axis of the band-like irradiation area.

In the laser irradiating apparatus (100) of the first aspect, the reflector (2) to be driven is smaller in the mass than the movable table (5) which is equivalent to the XY stage in the prior art or the laser oscillator (1) which is equivalent to the carbon heater in the prior art and than the optical system (3) and its location and movement at a high speed can thus be controlled with much ease. Also, since the timing for emitting the pulsed form of the laser beam (B1) from the laser oscillator (1) and the timing for changing the angle or location of the reflector (2) with the reflector driving means (6) are conducted by the timing controlling means (8), the band-like irradiation area of the laser beam can be shifted within a given area along the major axis of the band-like irradiation area.

According to a second aspect of the present invention, a laser irradiating apparatus (100) is provided comprising: a laser oscillator (1) for emitting a pulsed form of laser beam (B1) in response to a trigger signal (G); a rotary polygonal mirror (2) for reflecting the laser beam (B1); an optical system (3) for shaping the reflection (B2) of

the laser beam (B1) to form a band-like irradiation area (4) of which the major axis extends in a direction where the reflected laser beam (B2) is shifted by a change in the incident angle (θ) of the laser beam (B1) in relation to the reflection surface (2b) of the rotary polygonal mirror (2) on which the laser beam (B1) falls and projecting the band-like irradiation area (4) of the reflected laser beam (B2) on a semiconductor substrate (S); a movable table (5) for holding and moving the semiconductor substrate (S) along the minor axis of the band-like irradiation area (4); a rotary driving means (6) for rotating the rotary polygonal mirror (2) at a uniform speed; a rotation phase detecting means (7) for releasing a rotation phase data (Q) of the rotary polygonal mirror (2); and a timing controlling means (8) for controlling the timing for releasing the trigger signal (S) in response to the rotation phase data (Q) within a given range of time in order to change the incident angle (θ) within a given range of degrees.

In the laser irradiating apparatus (100) of the second aspect, the rotary polygonal mirror (2) is rotated at a speed which is uniform and equal to a ratio of one to the number of its mirrors and its implementation can be easy. Also, the timing for emitting the pulsed form of the laser beam (B1) from the laser oscillator (1) is timed with the phase of the rotation of the rotary polygonal mirror (2) and can

thus be controlled with ease. Accordingly, the band-like irradiation area of the laser beam can be shifted within a given area along the major axis of the band-like irradiation area easily and quickly.

(Advantages of the Invention)

The laser irradiating apparatus according to the present invention allows the location and movement at a high speed along the major axis of the band-like irradiation area of laser beam to be easily controlled, hence favorably attenuating the variations of the irradiation along the lengthwise direction of the band-like irradiation area which may be caused by a variation in the intensity of the laser beam along the major axis of the band-like irradiation area and tiny undulations at the surface of the substrate to be processed.

Brief Description of the Drawings

Fig. 1 is a structural explanatory view of a laser irradiating apparatus showing Embodiment 1 of the present invention;

Fig. 2 is a timing chart showing the action of a timing control circuit in Embodiment 1; and

Fig. 3 is an upper view showing a series of locations along the major axis of a band-like irradiation area of laser beam.

(Description of the Numerals)

1: laser oscillator, 2: rotary polygonal mirror, 3a:

homogenizer, 3b: mirror, 3c: lens, 4: band-like irradiation area, 5: movable table, 6: motor, 7: encoder, 8: timing control circuit, 100: laser irradiating apparatus.

Best Modes for embodying the Invention

The present invention will be described in mode detail referring to some embodiments shown in the relevant drawings. The present invention is not limited to the embodiments.

(Embodiment 1)

Fig. 1 a structural explanatory view of a laser irradiating apparatus 100 showing Embodiment 1 of the present invention.

The laser irradiating apparatus 100 comprises a laser oscillator 1 for emitting a pulsed form of laser beam B1 in response to a trigger signal G, a rotary polygonal mirror 2 for reflecting the laser beam B1, a group of homogenizer 3a, mirror 3b, and lens 3c for shaping the reflection B2 of the laser beam B1 to form a band-like irradiation area 4 of which the major axis extends in a direction along which the reflected beam B2 is shifted by a change in the incident angle θ of the laser beam B1 which falls on the reflecting surface 2b of the rotary polygonal mirror 2 and projecting the band-like irradiation area 4 of the reflected laser beam B2 onto a semiconductor substrate S, a movable table 5 for holding and moving the semiconductor substrate S along the major axis of the band-like irradiation area 4, a motor 6

for rotating the rotary polygonal mirror 2 at a uniform speed, an encoder 7 for producing a rotation phase data Q of the rotary polygonal mirror 2, and a timing control circuit 8 for modifying the timing of outputting the trigger signal G in response to the rotation phase data Q.

As its rotating shaft 2a extends vertically, the rotary polygonal mirror 2 is rotated on the horizontal plane. The laser beam B1 and the reflected laser beam B2 run in the horizontal direction. The semiconductor substrate S is placed horizontally. Accordingly, the reflected laser beam B1 is shifted by the mirror 3b from the horizontal direction to the vertical direction as having uniformly been increased in the intensity along both the major axis and the minor axis by the homogenizer 3a. The laser beam is converged along the major axis by the lens 3c and projected onto the semiconductor substrate S.

Fig. 2 is a timing chart illustrating the action of the timing control circuit 8.

The timing control circuit 8 is arranged responsive to the rotary phase data Q for generating a 45-degrees pulse output Q' which is indicative of the timing of action at which the incident angle θ is forty five degrees.

The period τ of the 45-degrees pulse output Q' is equal to a value determined by dividing the duration of time needed for one full turn of the rotary polygonal mirror 2 with the

number of mirrors in the rotary polygonal mirror 2.

The period τ is also equivalent to the average interval of time between emissions of the laser beam B1 of the pulsed form from the laser oscillator 1. The duration of time or pulse width when the laser oscillator 1 emits the laser beam B1 of the pulsed form is shorter than the period τ .

Assuming that the distance of shifting along the major axis of the band-like irradiation area 4 is (M+1), the timing control circuit 8 randomly produces one of the integers from 0 to M, referred to as m, and releases the trigger signal G after a duration $(\tau+(m-M/2)\delta /(M/2))$ from the output of the 45-degrees pulse Q'.

When the angle of rotation of the reflection surface 2b during the time δ is α, the incident angle θ is expressed by $(45^\circ -(m-M/2)\alpha /(M/2))$.

Fig. 2 illustrates an example at M=8 where the trigger signal G is released after the time of $(\tau+(m-4)\delta /4)$ and the incident angle θ is expressed by $(45^\circ -(m-4)\alpha /4)$.

Fig. 3 is a top view of the band-like irradiation area 4 shifted along the major axis.

Figs. 3a to 3i correspond to m=0~ m=8 at M=8.

The band-like irradiation area 4 is randomly shifted to nine different locations in an irradiation range R along the major axis.

When the length along the major axis of the band-like irradiation area 4 is L, a change in the incident angle θ for shifting the band-like irradiation area 4 by (R-L)/2 is equal to α .

The laser irradiating apparatus 100 of Embodiment 1 allows the rotary polygonal mirror 2 to carry out one full turn during the time equal to the multiplication of the number of mirrors at the period τ , hence being easy in the implementation. Also, as the laser beam B1 of the pulsed form is emitted from the laser oscillator 1 at intervals of $(\tau-\delta)$ at minimum, Embodiment 1 is highly feasible because of no more moving parts. Accordingly, the band-like irradiation area 4 can be shifted within the range R along the major axis at higher speeds.

(Embodiment 2)

The trigger signal G may be released at random within a range extending from $(\tau-\delta)$ to $(\tau+\delta)$ after the output of 45-degrees pulse Q'.

(Embodiment 3)

The rotary polygonal mirror 2 may be replaced by another mirror unit which is oscillated forward and backward along the direction of the laser beam B1. In this case, the timing of output of the trigger signal G can be modified according to the phase of the oscillation.

(Embodiment 4)

The rotary polygonal mirror 2 may be replaced by a galvano-mirror unit which is rocked for oscillation throughout a predetermined angle. In this case, the timing of output of the trigger signal G can be modified according to the phase of the oscillation of the galvano-mirror unit. (Embodiment 5)

The rotary polygonal mirror 2 may be replaced by a galvano-mirror unit while the trigger signal G is released at uniform intervals and the angle of the galvano-mirror unit is randomly modified throughout a predetermined angle as timed with the trigger signal G.

Industrial Applicability

The method of irradiating a laser beam and the laser irradiating apparatus according to the present invention can favorably be utilized in the action of fabricating or activating the semiconductor layers.

What is claimed is:

1. A laser irradiating apparatus (100) comprising:

a laser oscillator (1) for emitting a pulsed form of laser beam (B1); a reflector (2) for reflecting the laser beam (B1); an optical system (3) for shaping the reflection (B2) of the laser beam (B1) to form a band-like irradiation area (4) of which the major axis extends in a direction where the reflected laser beam (B2) is shifted by a change in the location or the angle (θ) of the reflection surface (2b) of the reflector (2), on which the laser beam (B1) falls, in relation to the laser beam (B1) and projecting the band-like irradiation area (4) of the reflected laser beam (B2) on a semiconductor substrate (S); a movable table (5) for holding and moving the semiconductor substrate (S) along the minor axis of the band-like irradiation area (4); a reflector driving means (6) for changing the location or the angle of the reflector (2); and a timing controlling means (8) for controlling the timing for changing the location or the angle of the reflector (2) with the reflector driving means (6) as well as the timing for emitting the pulsed form of the laser beam (B1) from the laser oscillator (1) in order to shift the band-like irradiation area within a given area along the major axis of the band-like irradiation area.

2. A laser irradiating apparatus (100) comprising:

a laser oscillator (1) for emitting a pulsed form of

laser beam (B1) in response to a trigger signal (G); a rotary polygonal mirror (2) for reflecting the laser beam (B1); an optical system (3) for shaping the reflection (B2) of the laser beam (B1) to form a band-like irradiation area (4) of which the major axis extends in a direction where the reflected laser beam (B2) is shifted by a change in the incident angle (θ) of the laser beam (B1) in relation to the reflection surface (2b) of the rotary polygonal mirror (2) on which the laser beam (B1) falls and projecting the band-like irradiation area (4) of the reflected laser beam (B2) on a semiconductor substrate (S); a movable table (5) for holding and moving the semiconductor substrate (S) along the minor axis of the band-like irradiation area (4); a rotary driving means (6) for rotating the rotary polygonal mirror (2) at a uniform speed; a rotation phase detecting means (7) for releasing a rotation phase data (Q) of the rotary polygonal mirror (2); and a timing controlling means (8) for controlling the timing for releasing the trigger signal (S) in response to the rotation phase data (Q) within a given range of time in order to change the incident angle (θ) within a given range of degrees.

Abstract