relatively low energy density, and the throughput can be increased by increasing the irradiated cross sectional area of the pulse laser light.

Example 1

[0027]

A description will now be given of an example and a comparative example of the present invention.

The laser annealing treatment apparatus 1 shown in FIGS. 1 and 2 were used, and the delayed quantity of the waveform shaping unit 13 was adjusted, thereby obtaining beams of pulse laser light respectively having pulse waveforms different in the rising time and the falling time. It should be noted the shape of the irradiated surface of the pulse laser light is a line beam shape of 465 ~~nm~~ mm and 0.4 mm in width, in this example.

FIG. 3 shows pulse waveforms of the respective pulse laser lights, and specifically describes rising times and falling times in charts. It should be noted that the falling times are described as pulse attenuation times in the charts.

[0028]

The pulse laser light having the pulse waveforms were changed in the pulse energy density, and irradiated the amorphous silicon film 100, and the crystal property was evaluated. It should be noted that the pulse energy density was changed mainly by adjusting the attenuation rate in the attenuator 11.

The evaluation of the crystal property was carried out by checking the surface of the crystallized silicon film by an electron microscope, and a surface formed by large crystal grains, and uniform in the grain diameter was determined as high quality. Crystal grains equal to or more than 200 nanometers, for example, were determined to be excellent.

Optimum crystallization pulse energy densities were obtained respectively in terms of the size and the uniformity of the crystal grains for each of the pulse waveforms. Upper and lower limits for the pulse energy density suitable for the crystallization were obtained for the pulse lasers light other than the pulse laser light having a rising time of 51 nanoseconds.

FIG. 4 shows the irradiation result obtained by using the pulse laser light of the

WHAT IS CLAIMED IS:

1. A laser annealing treatment apparatus to crystallize an amorphous silicon semiconductor film by irradiating a pulsed laser light to the amorphous silicon semiconductor film with relatively scanning the pulse laser light with respect to the amorphous silicon semiconductor film, the laser annealing treatment apparatus comprising:

a laser light source that outputs pulse laser light;

an optical system that shapes the pulse laser light, and leads the shaped pulse laser light to a semiconductor film subject to treatment; and

a stage to be set the semiconductor film to be irradiated by the pulse laser light,

wherein the pulse laser light irradiating the semiconductor film, which the pulse laser light is obtained by superimposing or synthesizing a plurality of pulsed laser lights, presents a rising time equal to or less than ~~35~~30 nanoseconds from 10% of the maximum height to the maximum height in the pulse energy density, and a falling time equal to or more than 80 nanoseconds from the maximum height to 10% of the maximum height.

2. The laser annealing treatment apparatus according to claim 1, wherein the rising time is equal to or less than 30 nanoseconds, and the falling time is equal to or more than 85 nanoseconds.

3. The laser annealing treatment apparatus according to claim 1 or 2, comprising a waveform shaping unit that shapes the pulse laser light output from the laser light source into a pulse waveform having the rising time and the falling time.

4. The laser annealing treatment apparatus according to claim 3, wherein the waveform shaping unit comprises beam splitting means that splits the pulse laser light output from the laser light source into a plurality of beams, delay means that delays each of the split beams, and beam synthesizing means that synthesizes the respective split beams.

~~5. The laser annealing treatment according to any one of claims 1 to 4, comprising a plurality of laser light sources, wherein beams of the pulse laser light output from the respective laser light are superimposed, thereby obtaining the pulse laser light irradiating the semiconductor film.~~

~~6. The laser annealing treatment according to any one of claims 1 to 5, wherein the semiconductor film to be irradiated by the pulse laser light is non-single-crystalline silicon.~~

~~7~~5. The laser annealing treatment apparatus according to any one of claims 1 to ~~4~~6, wherein the pulse laser light is excimer laser.

~~8.~~ 6. A laser annealing treatment method comprising:

obtaining pulse laser light which presents a rising time equal to or less than ~~35~~30

nanoseconds from 10% of the maximum height to the maximum height in the pulse energy density, with superimposing or synthesizing a plurality of pulsed laser lights, and a falling time equal to or more than 80 nanoseconds from the maximum height to
10% of the maximum height in a pulse waveform; and

a relatively scanning the pulse laser light with respect to ~~a~~ an amorphous silicon semiconductor film while the pulse laser light is irradiating the amorphous silicon semiconductor film, thereby carrying out surface treatment of the semiconductor film.