~~What is claimed is:~~CLAIMS

1. A laser annealing apparatus, comprising:

a laser beam generator for providing a stable single-pulse laser beam;

a cyclic delay unit for splitting the single-pulse laser beam into a plurality of pulsed laser beams;

an optical module for converging one or more of the plurality of pulsed laser beams on a substrate; and

a movable stage for providing the substrate with a movement in at least one degree of freedom~~.~~,

~~2. The laser annealing apparatus of claim 1,~~ wherein the cyclic delay unit at least includes a delayer, a beam splitter unit and an internal control module; and the internal control module is configured to control a time delay of the delayer and a beam-splitting ratio of the beam splitter unit.

~~3~~2. The laser annealing apparatus of claim ~~2~~1, wherein the cyclic delay unit further includes a plurality of optical fibers for transmitting laser beams between the beam splitter unit and the delayer.

4~~3~~. The laser annealing apparatus of claim ~~2~~1, wherein the delayer includes: two reflectors having parallel reflecting surfaces; and an entrance and an exit, each adjustable in an orientation or a position.

~~5~~4. The laser annealing apparatus of claim 4~~3~~, wherein the entrance and the exit are implemented as a receiver and a transmitter, respectively, or an entrance reflector and an exit reflector, respectively.

~~6~~5. The laser annealing apparatus of claim ~~4~~3, wherein the internal control module controls the time delay of the delayer by adjusting the orientation or position of any or both of the entrance and the exit.

~~7~~6. The laser annealing apparatus of claim ~~2~~1, wherein the beam splitter unit includes a plurality of first beam splitters having different transmittances and a pivot; and the internal control module controls the beam-splitting ratio of the beam splitter unit by driving the pivot to switch the first beam splitter in use.

~~8~~7. The laser annealing apparatus of claim ~~7~~6, wherein the first beam splitters are spaced a same distance from the pivot.

~~9~~8. The laser annealing apparatus of claim ~~2~~1, further comprising a master controller which is connected to the internal control module, wherein the master controller is configured to send a command indicative of a time delay and a beam-splitting ratio to the internal control module.

~~10~~9. The laser annealing apparatus of claim ~~9~~8, wherein the laser beam generator includes a laser, a dimmer, a second beam-splitter, an energy detector, a laser controller and an environmental control unit; the laser beam is provided by the laser and is split into a major part and a minor part by the second beam-splitter after the laser beam has passed through the dimmer; the major part of the laser beam enters the cyclic delay unit; the minor part of the laser beam enters the energy detector; the energy detector measures the energy of the minor part of the laser beam and transfers the measurement results to the laser controller; the environmental control unit obtains operating environment information of the laser and transfers the operating environment information to the laser controller; the laser controller controls the laser based on the measurement results from the energy detector and the operating environment information from the environmental

control unit; and the laser controller and the environmental control unit are both under control of the master controller.

~~11~~10. The laser annealing apparatus of claim ~~9~~8, wherein the optical module includes a beam expander, a beam homogenizer, a first focusing lens group, a third beam splitter, a second focusing lens group and a focal plane detector; each of the plurality of pulsed laser beams, exited from the cyclic delay unit, successively passes through the beam expander and the beam homogenizer and is then split into a first part and a second part by the third beam splitter; the first part of each of the plurality of pulsed laser beams passes through the first focusing lens group and is thereby directed onto a surface of the substrate; the second part of each of the plurality of pulsed laser beams passes through the second focusing lens group and is thereby directed onto the focal plane detector; the focal plane detector obtains focal plane information and outputs the focal plane information to the master controller; and the master controller controls movement of the movable stage based on the focal plane information, so as to move the substrate to an optimal focal plane position.

~~12~~11. A laser annealing method, comprising:

providing a stable single-pulse laser beam;

splitting the single-pulse laser beam into a plurality of pulsed laser beams according to a desired time delay and an energy ratio; and

irradiating a substrate successively with one or more of the plurality of pulsed laser beams to maintain a surface temperature of the substrate within a predetermined range~~.~~.

~~13. The laser annealing method of claim 12,~~ wherein splitting the single-pulse laser beam into the plurality of pulsed laser beams according to the desired time delay and the energy ratio includes:

a) selecting a first beam splitter according to a preset beam-splitting ratio;

b) splitting the single-pulse laser beam into two pulsed laser beams with the first beam splitter, irradiating the substrate with one of the two pulsed laser beams, and delaying the other of the two pulsed laser beams by the desired time delay with a delayer;

c) splitting the other of the two pulsed laser beams that has exited the delayer into further two pulsed laser beams with the first beam splitter, irradiating the substrate with one of the further two pulsed laser beams, and delaying the other of the further two pulsed laser beams by the desired time delay with the delayer; and

d) repeating step c), or selecting another first beam splitter according to another preset beam-splitting ratio and repeating step c).

~~14~~12. The laser annealing method of claim ~~13~~11, wherein the delayer includes: two reflectors having parallel reflecting surfaces; and an entrance and an exit, each adjustable in an orientation or a position.

~~15~~13. The laser annealing method of claim ~~14~~12, wherein adjusting the orientation or the position of any or both of the entrance and the exit results in an adjustment in the time delay realized by the delayer.

~~16~~14. The laser annealing method of claim ~~14~~12, wherein the exit and the entrance are implemented as a transmitter and a receiver, respectively, or an exit reflector and an entrance reflector, respectively.