LASER PROCESS DEVICE

BACKGROUND

[0001] The present disclosure relates to a laser process device, and more particularly, to a laser process device used in laser lift off (LLO) processing in which a thin film is separated from a substrate.

[0002] Due to recent improvements in reliability and output of excimer laser beams, their range of application has been expanded even into the field of semiconductor material processing. In particular, in the forming of devices such as light emitting diodes (LEDs), thin film separation processing from wafers using laser beams is widely employed, and is referred to as laser lift off (LLO) processing. FIG. 1 is a conceptual view of a related art laser process device for performing LLO processing.

[0003] Referring to FIG. 1, a laser process device includes a krypton fluoride (KrF) excimer laser 1 with a 248 nm wavelength, and an optical system 2 formed with a plurality of lenses. Below, a description will be given of laser lift off processing using the laser process device 9 above. First, when the KrF excimer laser 1 emits a laser beam, the laser beam passes through the optical system 2 to assume a suitable form and intensity, and is then radiated onto a processing object P that includes a sapphire window P1 and a gallium nitride (GaN)-based epilayer P2. Here, if the energy of the laser beam is lower than the band gap of sapphire (approximately 10.0 eV), it is greater than the band gap of GaN (approximately 3.3 eV), so that the laser beam is not absorbed by the sapphire window P1 and is transmitted as-is to be absorbed by the GaN-based epilayer P2. The thus-absorbed laser beam energy heats

and partitions the contacting surfaces of the sapphire window and the epilayer P2 to separate the sapphire window P1 and the epilayer P2.

[0004] By-products O in the form of fumes and particles are generated from separation of adjoined surfaces during the above-described laser lift off processing, and these by-products O, as illustrated in FIG. 1, adhere to the surface of a lens or the top surface of the sapphire window. When by-products are thus attached, a portion of the laser beam emitted toward the epilayer P2 is absorbed en route by the by-products O, so that the energy profile of the laser beam that reaches the surface of the epilayer is non-uniform. Thus, cracks or other defects are generated from stress at portions on the epilayer surface where excessive energy is absorbed, and separation between the sapphire window and epilayer does not occur at portions that absorb small energy levels, resulting in problems of reduced quality and yield for manufactured products.

[0005] Further, contamination or damage to other components within the laser process device due to the by-products O results in the problem of reduced durability of the laser process device.

SUMMARY

[0006] The present disclosure provides a laser process device with an improved structure for preventing reductions in product quality and yield, or contamination of nearby components due to generation of by-products during processing of a processing object.

[0007] According to an exemplary embodiment, a laser process device includes: a laser beam light source configured to emit a laser beam; an optical system configured to form a shape and energy profile of a laser beam emitted from

the laser beam light source; a stage on which a processing object is positioned, the processing object processed through radiating the laser beam formed by the optical system thereon; and a suction unit disposed in a travel path of the laser beam formed by the optical system to transmit the laser beam therethrough, and configured to suction by-products generated during processing of the processing object.

[0008] The suction unit may include: a housing including a through-hole defined therethrough for the laser beam to pass through, and an exhaust hole defined therethrough for the by-products to flow through; a beam splitter coupled to the housing to close the through-hole; and a fan configured to suction the by-products to the exhaust hole, wherein the laser process device may further include a monitoring unit configured to monitor the laser beam using a portion of the laser beam reflected by the beam splitter.

[0009] The suction unit may include: a housing including a through-hole defined therethrough for the laser beam to pass through, an exhaust hole communicating with the through-hole for the by-products to flow through, and a nozzle portion communicating with the through-hole and configured to discharge nonvolatile gas supplied from an outside toward the exhaust hole; and a fan configured to suction the by-products to the exhaust hole.

[0010] The housing may further include a beam splitter coupled to close the through-hole, and a discharge portion communicating with the through-hole and configured to discharge a nonvolatile gas toward the beam splitter.

[0011] The laser processing may further include a filter disposed in a flow path of the by-products between the exhaust hole and the fan to filter the by-products.

[0012] The laser process device may further include: an aligner configured to align the processing object and the laser beam; and a focusing unit configured to

align a focal point of the laser beam on the processing object.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Exemplary embodiments can be understood in more detail from the following description taken in conjunction with the accompanying drawings, in which:

[0014] FIG. 1 is a conceptual view of a related art laser process device;

[0015] FIG. 2 is a conceptual view of a laser process device according to an exemplary embodiment;

[0016] FIG. 3 is a perspective view of the suction unit in FIG. 2;

[0017] FIG. 4 is a sectional view of FIG. 3 taken along line IV-IV;

[0018] FIG. 5 is a sectional view of the laser process device cut along line V-V in FIG. 4;

[0019] FIG. 6 is a block diagram illustrating the operating principle of an alignment unit; and

[0020] FIG. 7 is a block diagram illustrating the operating principle of a focusing unit.

DETAILED DESCRIPTION OF EMBODIMENTS

[0021] Hereinafter, specific embodiments will be described in detail with reference to the accompanying drawings.

[0022] FIG. 2 is a conceptual view of a laser process device according to an exemplary embodiment, FIG. 3 is a perspective view of the suction unit in FIG. 2, FIG. 4 is a sectional view of FIG. 3 taken along line IV-IV, and FIG. 5 is a sectional view of the laser process device cut along line V-V in FIG. 4.

[0023] Referring to FIGS. 2 through 5, a laser process device 100 includes a laser beam light source 10, an attenuator 20, an optical system 30, a stage 40, a suction unit 50, a monitoring unit 60, and an image capture device 70.

[0024] As a component for the process of generating a laser beam, the laser beam light source 10 may employ a KrF excimer laser, an argon fluoride (ArF) excimer laser, or various other types according to the laser beam wavelength to be used.

[0025] The attenuator 20 is disposed in the travel path of the laser beam and controls the intensity of the laser beam. Being a well-known device, the attenuator 20 will not be described.

[0026] The optical system 30 is disposed along the travel path of the laser beam emitted from the laser beam light source 10, and forms the shape and the energy profile of the laser beam. The optical system 30 according to some embodiments includes a beam expansion telescope 31 that forms the shape of a laser beam, a beam homogenizer 32 that uniformly distributes energy of the formed laser beam, and a projection lens 33 that adjusts the focal point of the laser beam. Also, a mirror 34 that changes the travel direction of a laser beam by reflecting the laser beam, a mask 35 that masks the sectional edges of a laser beam that passes through the beam homogenizer 32, and a field lens 36 may be provided as required. Since the optical system 30 described above is a publically known configuration that is disclosed in Korean Patent No. 10-0724540, etc., a description thereof in further detail will not be provided.

[0027] The stage 40 is disposed in the travel path of the laser beam that passes through the optical system 30. A processing object P is disposed on the top surface of the stage 40 to be processed when the laser beam is radiated. The stage 40

is connected to a stage driver. The stage driver is electrically connected to the motion controller, and moves the stage 40 horizontally and vertically according to received moving signals output from the motion controller.

[0028] As a component for suctioning by-products O generated during processing of a processing object P, the suction unit 50 is disposed in the travel path of the laser beam. The suction unit 50 includes a housing 51, a beam splitter 52, a fan 53, a filter 54, and a cartridge 55.

[0029] The housing 51 is disposed in the travel path of the processing object P, and includes a through-hole 511, an exhaust hole 512, a nozzle portion 513, and a discharge portion 514. The through-hole 511 is defined vertically through the center of the housing 51. The laser beam passes through the through-hole 511. The exhaust hole 512 is defined through an inner side of the housing 51 defined by the through-hole 511. The exhaust hole 512 communicates with the through-hole 511 and an exhaust duct 515 coupled to the housing 51. The nozzle portion 513 communicates with the through-hole 511 and a first gas supply line 516 installed at a side of the housing 51. The nozzle portion 513 discharges a nonvolatile gas supplied from the outside through the first gas supply line 516 toward the exhaust hole 512. When discharged nonvolatile gas enters the exhaust hole 512, by-products O flow into the exhaust hole 512 together with the nonvolatile gas. The discharge portion 514 communicates with the through-hole 511 and a second gas supply line 517 installed on a side of the housing 51. The discharge portion 514 discharges nonvolatile gas supplied from the outside through the second gas supply hole 517 toward a beam splitter 52 (to be described). The discharged nonvolatile gas flows downward along the beam splitter 52 and through-hole 511. Accordingly, because the undersurface of the beam splitter 52 is in a nonvolatile gas atmosphere, by-products O flow

downward together with nonvolatile gas.

[0030] The beam splitter 52 is formed in a plate shape, and is disposed at a 45° slope to the travel direction of the laser beam in the travel path of the laser beam. The beam splitter 52 is coupled to a top surface of the housing 51 and blocks the through-hole 511. The beam splitter 52 transmits and reflects the incident laser beam. In particular, in some embodiments, 95% of an incident laser beam is transmitted, and 5% is reflected.

[0031] The fan 53 is installed within the exhaust duct 515. The fan 53 suctions by-products O through the through-hole 511 and the exhaust hole 512.

[0032] The filter 54 is installed within the exhaust duct 515 and disposed in the exhaust passage for by-products O between the exhaust hole 512 and the fan 53. The filter 54 filters gas that is exhausted through the exhaust duct 515 to remove by-products O contained therein.

[0033] The cartridge 55 has a storage space 551, and is detachably coupled to the exhaust duct 515. The cartridge 55 is disposed below the filter 54, and by-products O of a larger size that cannot pass through the filter collect in the storage space 551 of the cartridge 55. Also, a level sensor 56, formed of a photoemitter 561 and a photoreceiver 562, is installed in the storage space 551 of the cartridge 55. The photoemitter 561 emits light that is received by the photoreceiver 562 disposed opposite the photoemitter 561. When more than a predetermined quantity of by-products O is amassed in the storage space 551, the light emitted from the photoemitter 561 is blocked by the by-products O and is not received by the photoreceiver 562, whereupon an alerting unit (not shown) electrically connected to the level sensor 56 issues a predetermined signal to empty the cartridge 55.

[0034] A monitoring unit 60 collects the portion of the laser beam reflected

by the beam splitter 52 to monitor the laser beam. In particular, a monitoring unit 60 includes a beam profiler 61 and an energy meter 62, according to some embodiments. The beam profiler 61 is disposed in the travel path of the laser beam reflected by the beam splitter 52 to collect the reflected laser beam. The beam profiler 61 measures the energy profile of the reflected portion of the laser beam. The energy meter 62 is disposed in the travel path of the laser beam reflected by the beam splitter 52 and collects the reflected laser beam. The energy meter 62 measures the intensity of the reflected laser beam. By thus measuring the energy profile and intensity of the reflected laser beam, the energy profile and intensity of the laser beam transmitted through the beam splitter 52 can be known.

[0035] The image capture device 70 is disposed at a top of the through-hole 511 to capture the processing of a processing object P. When the image capture device 70 is connected to a display device, processing of processing objects can be checked in real time.

[0036] The laser process device 100 further includes an aligning unit 80 and a focusing unit 90. FIG. 6 is a block diagram illustrating the operating principle of an alignment unit, and FIG. 7 is a block diagram illustrating the operating principle of a focusing unit. A description with reference to FIGS. 6 and 7 will be provided below.

[0037] An aligner 80 is for aligning a processing object P with a laser beam, and more particularly, disposes a point to be processed in the travel path of a laser beam. An aligner 80 according to some embodiments includes a viewer 81 and a viewer controller 82. The viewer 81 is disposed above a processing object P. When the processing object P is moved below the viewer 81, the viewer 81 detects marks in the processing object P and uses them to measure horizontal positions of processing

points, and transmits the measured positions to the viewer controller 82. The viewer controller 82 calculates the difference between a processing point position transmitted from the viewer 81 and the radiated position of the laser beam, and outputs a corresponding control signal to a motion controller 42. The motion controller 42 that receives the control signal outputs a corresponding moving signal to a stage driver 41, and the stage driver 41 receives the moving signal and moves the stage 40 accordingly in a horizontal direction.

[0038] A focusing unit 90 is for aligning the focal point of the laser beam with the processing object P, and more particularly, is for matching the focal point of the laser beam to a processing point. A focusing unit 90 according to some embodiments includes a focusing portion 91 and a focusing controller 92. The focusing portion 91 is disposed above the processing object P. When the processing object P is moved below the focusing portion 91, the focusing portion 91 detects the curvature of the processing object P and uses the curvature to measure the vertical position of a processing point, and transmits the measured position to the focusing controller 92. The focusing controller 92 calculates the difference between the position of the processing point transmitted from the focusing portion 91 and the focal point of the laser beam, and outputs a corresponding control signal to the motion controller 42. Then, the motion controller 42 that receives the control signal outputs a moving signal corresponding to the control signal to the stage driver 41, whereupon the stage driver 41 receives the moving signal and moves the stage 40 accordingly in a vertical direction.

[0039] Below, a description will be given in which a laser process device 100 as configured above is used to perform laser lift off processing.

[0040] As illustrated in FIG. 4, a laser beam transmitted through an optical

system 30 travels downward to reach a beam splitter 52. Of the laser beam that reaches the beam splitter 52, 5% is reflected to proceed horizontally, and 95% is transmitted through the beam splitter 52 and radiated on a processing object P. As described in the related art, the laser beam radiated onto the processing object P passes through a sapphire window P1, after which it is absorbed by a GaN-based epilayer P2 to heat and partition the contacting surface of the epilayer P2, thereby separating the sapphire window P1 and the epilayer P2. When the epilayer P2 is separated, by-products O are generated in the form of fumes and particles.

[0041] The generated by-products O are made to flow through the through-hole 511 and exhaust hole 512 (illustrated in FIG. 4) by means of suctioning force generated by the fan 53 and nonvolatile gas discharged from the nozzle portion 513 and the discharge portion 514, and are filtered by the filter 54. In further detail, by-products O that are made to flow upward through the through-hole 511 by means of the suctioning force from the fan 53 mostly enter the exhaust hole 512 together with the nonvolatile gas discharged from the nozzle portion 513 toward the exhaust hole 512, and are then trapped by the filter 54 while flowing through the exhaust duct 515. Also, a portion of the by-products O that does not enter the exhaust hole 512 but flows upward through the through-hole 511 is made to flow downward again by means of nonvolatile gas discharged from the discharge portion 514 and downward along the beam splitter 52 and through-hole 511, and then enters the exhaust hole 512 by means of the suctioning force of the fan 53, after which it is filtered by the filter 54.

[0042] When the monitoring unit 60 is used, the energy profile and intensity of the laser beam can be measured, and the laser beam can be radiated on a precise location through the use of the aligner 80 and the focusing unit 90.

[0043] As described above, because a suction unit 50 is provided on a laser process device 100 according to some embodiments, by-products O generated during processing can be prevented from attaching to a processing object or to nearby components. In particular, the suction unit 50 is formed not only of a fan 53 that generates suctioning force, but also of a nozzle portion 513 that discharges nonvolatile gas to move by-products O toward an exhaust hole 512, and a discharge portion 514 that discharges nonvolatile gas to prevent the by-products O from flowing toward the beam splitter 52. Accordingly, by-products O can efficiently be suctioned into the exhaust duct to simultaneously prevent attaching of by-products O to the beam splitter 52. Therefore, the energy of the laser beam that reaches the epilayer P2 is prevented from being non-uniform, so that a superior quality product can be manufactured and manufacturing yield of the laser process device 100 can be increased. Also, contamination of and damage to the laser process device by by-products O can be prevented, and durability of the laser process device is improved.

[0044] Further, a beam splitter 52 is installed in a suction unit 50. Accordingly, even without the addition of separately-installed components for separating a laser beam to be measured in beam profile and intensity, the laser beam profile and intensity can be measured in real time during the performing of laser beam lift off processing using the laser beam radiated onto the beam splitter 52. Accordingly, space utilization of the laser process device is superb, and the configuration thereof is simplified.

[0045] According to above-described configurations, by-products generated during processing of a processing object can effectively be suctioned into a suction unit. Accordingly, processing conditions being adversely affected by by-products can be prevented, and thus, the quality of the manufactured product is improved, and

the manufacturing yield of the laser process device is increased.

[0046] Also, by preventing contamination of or damage to the laser process device from by-products, the durability of the laser process device is improved.

[0047] Although the laser process device has been described with reference to the specific embodiments, it is not limited thereto. Therefore, it will be readily understood by those skilled in the art that various modifications and changes can be made thereto without departing from the spirit and scope of the present invention defined by the appended claims.

WHAT IS CLAIMED IS:

1. A laser process device comprising:

a laser beam light source configured to emit a laser beam;

an optical system configured to form a shape and energy profile of a laser beam emitted from the laser beam light source;

a stage on which a processing object is positioned, the processing object processed through radiating the laser beam formed by the optical system thereon; and

a suction unit disposed in a travel path of the laser beam formed by the optical system to transmit the laser beam therethrough, and configured to suction by-products generated during processing of the processing object.

2. The laser process device of claim 1, wherein the suction unit comprises:

a housing comprising a through-hole defined therethrough for the laser beam to pass through, and an exhaust hole defined therethrough for the by-products to flow through;

a beam splitter coupled to the housing to close the through-hole; and

a fan configured to suction the by-products to the exhaust hole,

wherein the laser process device further comprises a monitoring unit configured to monitor the laser beam using a portion of the laser beam reflected by the beam splitter.

3. The laser process device of claim 1, wherein the suction unit comprises:

a housing comprising a through-hole defined therethrough for the laser beam to pass through, an exhaust hole communicating with the through-hole for the by-products to flow through, and a nozzle portion communicating with the through-hole and configured to discharge nonvolatile gas supplied from an outside toward the exhaust hole; and

a fan configured to suction the by-products to the exhaust hole.

4. The laser process device of claim 3, wherein the housing further comprises a beam splitter coupled to close the through-hole, and a discharge portion communicating with the through-hole and configured to discharge a nonvolatile gas toward the beam splitter.

5. The laser process device of claim 2 or 3, further comprising a filter disposed in a flow path of the by-products between the exhaust hole and the fan to filter the by-products.

6. The laser process device of any one of claims 1 through 4, further comprising:

an aligner configured to align the processing object and the laser beam; and

a focusing unit configured to align a focal point of the laser beam on the processing object.