

OPTICS PURGE DEVICE

BACKGROUND

I. Technical Field

[0001] Embodiments of the present invention relate generally to a laser processing apparatus and, more particularly, relate to devices adapted to reduce or prevent accumulation of contaminants on optical surfaces of components within a laser processing apparatus.

II. Discussion of the Related Art

[0002] A laser processing apparatus for processing a workpiece (e.g., by drilling, cutting, splitting, routing, etc., the workpiece) typically includes components such as a laser source, conditioning optics (e.g., for expanding, collimating, filtering, polarizing, focusing, attenuating, etc., a beam of laser energy generated by the laser source), one or more beam deflection systems (i.e., for imparting relative movement of the beam of laser energy relative to the workpiece), a scan lens for focusing the beam of laser energy delivered to the workpiece, and one or more mirrors for guiding the beam of laser energy from the laser source to the scan lens. These components are typically housed within one or more enclosures yet the ambient environment in which the aforementioned components are located can contain particulates such as dust, smoke or other contaminants, which can settle on optical surfaces of the components. As used herein, an “optical surface” refers to a surface of a component which is intended to be irradiated by the beam of laser energy during operation of the laser processing apparatus. The accumulation of contaminants on the optical surface of a component can increase the susceptibility of the optical surface to damage in the presence of the beam of laser energy.

[0003] There exist purge systems which are used to direct a flow of purge gas (e.g., clean dry air, nitrogen, etc.) onto the optical surfaces to reduce or prevent contaminants from accumulating thereon. Such purge systems typically operate by flowing the purge gas against the optical surface at a sufficiently high flow rate to disperse or advect the contaminants from the optical surface. However, known conventional purge system undesirably influence position of the beam path along which the beam of laser energy propagates in the vicinity of the optical surface. That is, the conventional purge systems can create undesirable beam pointing instability, which results in the workpiece being processed with degraded quality or accuracy.

SUMMARY OF THE INVENTION

[0004] According to an aspect of the present disclosure, an optics purge device is provided. The optics purge device includes a purge device body including an optical port extending therethrough, a purge gas inlet in the purge device body, a primary distribution plenum in the purge device body and in fluid communication with the purge gas inlet, a diffuser channel in the purge device body and in fluid communication with the primary distribution plenum, wherein the diffuser channel extends around the optical port, and a diffuser accommodated within the diffuser channel.

[0005] According to another aspect of the present disclosure, an optical assembly is provided. The optical assembly includes an optics purge device including a purge device body having an optical port extending therethrough, a purge gas inlet in the purge device body, a primary distribution plenum in the purge device body and in fluid communication with the purge gas inlet, a diffuser channel in the purge device body and in fluid communication with the primary distribution plenum, and a diffuser accommodated within the diffuser channel. The optical assembly also includes an optical component mount configured to support an optical component, and a sealing member disposed between the optics purge device and the optical component mount. A purge region is defined between the purge device body, the optical component mount and an optical component supportable by the optical component mount.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 illustrates a section view of an optics purge device, according to an embodiment of the present invention.

[0007] FIG. 2A illustrates a cross-sectional view of an optics purge device, according to an embodiment.

[0008] FIG. 2B illustrates a bottom view of the optics purge device of FIG. 2A, according to an embodiment.

[0009] FIG. 3 illustrates a pressure distribution within the optics purge device of FIG. 1.

[0010] FIG. 4 illustrates a section view of the optics purge device of FIG. 1 in an alternative arrangement, according to an embodiment.

DETAILED DESCRIPTION

[0011] Example embodiments are described herein with reference to the accompanying FIGS. Unless otherwise expressly stated, in the drawings the sizes, positions, etc., of components, features, elements, etc., as well as any distances therebetween, are not necessarily to scale, but are exaggerated for clarity.

[0012] The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It should be recognized that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. Unless otherwise specified, a range of values, when recited, includes both the upper and lower limits of the range, as well as any sub-ranges therebetween. Unless indicated otherwise, terms such as “first,” “second,” etc., are only used to distinguish one element from another. For example, one node could be termed a “first node” and similarly, another node could be termed a “second node”, or vice versa. The section headings used herein are for organizational purposes only and are not to be construed as limiting the subject matter described.

[0013] Unless indicated otherwise, the term “about,” “thereabout,” “substantially,” etc., means that amounts, sizes, formulations, parameters, and other quantities and characteristics are not and need not be exact, but may be approximate and/or larger or smaller, as desired, reflecting tolerances, conversion factors, rounding off, measurement error and the like, and other factors known to those of skill in the art.

[0014] Spatially relative terms, such as “below,” “beneath,” “lower,” “above,” and “upper,” and the like, may be used herein for ease of description to describe one element or feature's relationship to another element or feature, as illustrated in the FIGS. It should be recognized that the spatially relative terms are intended to encompass different orientations in addition to the orientation depicted in the FIGS. For example, if an object in the FIGS. is turned over, elements described as “below” or “beneath” other elements or features would then be oriented “above” the other elements or features. Thus, the exemplary term “below” can encompass both an orientation of above and below. An object may be otherwise oriented (e.g., rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein may be interpreted accordingly.

[0015] Like numbers refer to like elements throughout. Thus, the same or similar numbers may be described with reference to other drawings even if they are neither mentioned nor described in the corresponding drawing. Also, even elements that are not denoted by reference numbers may be described with reference to other drawings.

[0016] It will be appreciated that many different forms and embodiments are possible without deviating from the spirit and teachings of this disclosure and so this disclosure should not be construed as limited to the example embodiments set forth herein. Rather, these

examples and embodiments are provided so that this disclosure will be thorough and complete, and will convey the scope of the disclosure to those skilled in the art.

[0017] Embodiments of the present invention provide an optical purge device adapted to reduce or prevent accumulation of contaminants on an optical surface. As will be described in greater detail below, the optical purge device is configured to introduce purge gas near an optical surface in a manner that generate a relatively high-pressure, low-flow rate region relatively proximate to the optical surface and a relatively low-pressure, high-flow rate region relatively distant from the optical surface. The optical purge device is further configured to exhaust the introduced purge gas along a direction that is generally coaxial with beam path along which the beam of laser energy propagates near the optical surface.

[0018] Referring to FIGS. 1, 2A and 2B, an optical purge device according to one embodiment, such as optics purge device 100, includes a purge device body 102 and a diffuser 104. The purge device body 102 includes an optical port 106 extending therethrough, a diffuser channel 200 (best shown in FIGS. 2A and 2B) formed in a lower surface thereof, a purge gas inlet 108, and a primary distribution plenum 110 formed in an upper surface of the diffuser channel 200 and in fluid communication with the purge gas inlet 108.

[0019] The optical port 106 extends from an upper surface of the purge device body 102 to the lower surface thereof and is of adequate size or width to permit a beam of laser energy to propagate therethrough to (or from) an optical component (e.g., optical component 118, as shown in FIG. 1). Generally, the optical component 118 can be a component such as a lens, window, waveplate, polarizer, acousto-optic (AO) device (e.g., an AO modulator, AO deflector), an electro-optic (EO) device (e.g., an EO modulator, EO deflector), a mirror, a diffractive optical element (DOE), a diffuser, a beam splitter, a diffraction grating, or the like or any combination thereof). Constructed as described above, a beam of laser energy is propagatable through the optical port 106 to the optical surface 118a of optical component 118. Thus if the optical component 118 was provided as a reflective component such as a mirror, then a beam of laser energy propagating through the optical port 106 to the optical surface 118a would be reflected back through the optical port 106 of the optics purge device 100. If the optical component 118 was provided as transmissive component such as window, lens, waveplate, AO device, beam splitter, etc. , then the beam of laser energy propagating through the optical port 106 to the optical surface 118a (also referred herein as a “front optical surface”) would be transmitted through the optical component 118 and exit the optical component 118 at optical surface 118b (also referred herein as a “rear optical surface”) opposite from the optical surface 118a.

[0020] Generally, the beam of laser energy can be manifested as a series of laser pulses or as a continuous (CW) or quasi-continuous (QCW) beam of laser energy, which propagate along a beam path into the optical port 106. The position of the beam path may be fixed, or

may be variable (e.g., upon being selectively deflected by any suitable or known beam positioner such as a galvanometer mirror, fast steering mirror, an acousto-optic deflector, an electro-optic deflector, a deformable mirror, or the like or any combination thereof).

Although the optical port 106 is illustrated as cylindrical in shape, it will be appreciated that the optical port 106 may be configured in any desired or suitable manner. For example, the optical port 106 may have a frustroconical shape (e.g., where the width of the optical port 106 at a location relatively near to the optical component 118 is less than the width of the optical port 106 at a location relatively far from the optical component 118).

[0021] The diffuser channel 200 is formed within the purge device body 102 and extends around the optical port 106 (e.g., so as to be spaced apart from the optical port 106 along a width or radial direction of the optical port 106). As best shown in FIG. 2A, the diffuser channel 200 has a uniform annular structure, but it will be appreciated that the diffuser channel 200 can have any other suitable shape.

[0022] The primary distribution plenum 110 formed in an upper surface of the diffuser channel 200 and is in fluid communication with the purge gas inlet 108 and the diffuser channel 200. The purge gas inlet 108 is configured to receive a purge gas (e.g., air) from an external purge gas source (not shown) in any known or suitable manner (e.g., via a hose or tube, or the like).

[0023] The diffuser 104 is formed of a porous material (e.g., sintered aluminum) through which purge gas can flow. The diffuser 104 may have a generally annular shape and be sized so as to fit within the diffuser channel 200. As best shown in FIG. 1, an outer sidewall of the diffuser 104 may have an outer gland 112 (or groove) formed therein, which extends around the outer perimeter of the diffuser 104. Likewise, an inner sidewall of the diffuser 104 may have an inner gland 114 (or groove) formed therein, which extends around the inner perimeter of the diffuser 104. Although not shown, an outer sealing member (e.g., an O-ring) may be held within the outer gland 112 and an inner sealing member (e.g., an O-ring) may be held within the inner gland 114. The outer and inner sealing members may be used to hold the diffuser 104 within the diffuser channel 200.

[0024] As best shown in FIG. 1, when the diffuser 104 is accommodated within the diffuser channel 200, the outer sidewall channel of the diffuser 104 and a sidewall of the diffuser channel 200 adjacent to the diffuser 104 form an outer secondary distribution plenum. Likewise, the inner sidewall channel of the diffuser 104 and a sidewall of the diffuser channel 200 adjacent to the diffuser 104 form an inner secondary distribution plenum. The diffuser 104 has a width that is greater than a width of the primary distribution plenum 110 and, as a result, the diffuser 104 is located outside the primary distribution plenum 110.

[0025] Purge gas received into the purge gas inlet 108 is conveyed into the primary distribution plenum 110 and, thereafter into the diffuser channel 200. When installed within the diffuser channel 200, the diffuser 104 acts to pressurize the primary distribution plenum 110, thereby enhancing the uniformity with which purge gas flows into the diffuser 104. The diffuser 104 thus acts to pressurize the outer and inner secondary distribution plenums, thereby further enhancing the uniformity with which purge gas flows into the diffuser 104. Ultimately, however, purge gas flowing through the diffuser 104 exits the diffuser 104 (and diffuser channel 200) in a uniform (or at least substantially uniform) manner from the lower surface of the purge device body 102.

[0026] Referring to FIG. 1, the optics purge device 100 is adapted to be coupled to (e.g., attached to or biased against) an optical component mount 116, to which an optical component 118 has been mounted, by any suitable or known technique. When the optics purge device 100 is coupled to the optical component mount 116 to which an optical component 118 has been mounted, a purge region 120, which is adjacent to an optical surface 118a of optical component 118 and in fluid communication with the optical port 106, is enclosed by the optics purge device 100, the optical component mount 116 and optical component 118.

[0027] Optionally, a sealing member 122 (e.g., an O-ring) may be provided between the optics purge device 100 and the optical component mount 116 so as to prevent or otherwise reduce the flow of a gas (e.g., air) into the purge region 120 from a location outside the optics purge device 100. Additionally or alternatively, the presence of the sealing member 120 between the optics purge device 100 and the optical component mount 116 may prevent or otherwise reduce the flow of purge gas introduced into the purge region 120 from the diffuser 104 between the optics purge device 100 and the optical component mount 116 thereby ensuring that the purge gas at least predominantly exits the purge volume 120 through the optical port 106.

[0028] Although the optics purge device 100 is illustrated as being coupled to the optical component mount 116 to which an optical component 118 has been mounted, it will be appreciated that the optics purge device 100 may be directly coupled to (e.g., attached to or biased against) the optical component 118 by any suitable or known technique. In this case, the sealing member 122 may, optionally, be provided between optical component 118 and the optics purge device 100 to provide sealing as discussed above.

[0029] Referring to FIG. 3, when purge gas is introduced into the optics purge device 100 (e.g., indicated by arrow 300), the purge gas flows into the primary distribution plenum 110, diffuser 104 before entering into the purge region 120. Dimensions of the optics purge device 100 (e.g., including dimensions of the optical port 106 and diffuser channel 200) are selected such that the purge gas introduced into the purge region 120 maintains the purge

region 120 at a relatively high pressure as compared to a pressure within the optical port 106 (areas of the purge region 120 colored red, orange and yellow have a higher pressure than areas of the optical port 106 colored green, light blue and dark blue). It will be appreciated that, within areas of relatively high pressure, movement of purge gas is relatively slow, whereas movement of purge gas is relatively high within areas of relatively low pressure. Given the configuration described above, purge gas introduced into the purge region 120 by the optics purge device 100 acts to create a zone of slow-moving, high-pressure purge gas adjacent to the optical component 118, which exits the optics purge device 100 through a zone of fast-moving, low-pressure purge gas in the optical port 106. If the beam of laser energy propagates through the optical port 106 along an axis that is parallel to (or coaxial with) the longitudinal axis of the optical port 106, then the flow of purge gas through the optical port 106 can be characterized as being parallel to or coaxial with (or at least substantially parallel to or coaxial with) the axis of the beam of laser energy propagating through the optical port 106. Further, depending on one or more factors such as the flow rate of the purge gas, the configuration of the diffuser 104, the dimensions of the purge region 120, the dimensions of the optical port 106, the surface topology of the optical surface 118a, etc., the flow of purge gas within the purge region 120 and/or optical port can be characterized as being laminar (or at least substantially laminar). Entry of particulates such as dust, smoke or other contaminants in the ambient environment outside the optics purge device 100 near optical port 106 into the purge region 120 can thus be prevented or otherwise reduced, thereby preventing or otherwise reducing the accumulation of such contaminants on the front optical surface 118a of optical component 118.

[0030] Although FIGS. 1 and 3 illustrate the optics purge device 100 as being provided to prevent or otherwise reduce the accumulation of contaminants on the front optical surface 118a of optical component 118, it will be appreciated that the optics purge device 100 may alternatively be provided to prevent or otherwise reduce the accumulation of contaminants on the rear optical surface 118b of optical component 118 (e.g., as shown in FIG. 4). It will also be appreciated that multiple optics purge devices, such as optics purge device 100, may be provided, where a first optics purge device is provided to prevent or otherwise reduce the accumulation of contaminants on the front optical surface 118a of optical component 118 (e.g., as shown in FIG. 1) and a second optics purge device is provided to prevent or otherwise reduce the accumulation of contaminants on the rear optical surface 118b of optical component 118 (e.g., as shown in FIG. 4).

[0031] The foregoing is illustrative of embodiments and examples of the invention and is not to be construed as limiting thereof. Although a few specific embodiments and examples have been described with reference to the drawings, those skilled in the art will readily appreciate that many modifications to the disclosed embodiments and examples, as well as other embodiments, are possible without materially departing from the novel teachings and

advantages of the invention. Accordingly, all such modifications are intended to be included within the scope of the invention as defined in the claims. For example, skilled persons will appreciate that the subject matter of any sentence, paragraph, example or embodiment can be combined with subject matter of some or all of the other sentences, paragraphs, examples or embodiments, except where such combinations are mutually exclusive. The scope of the present invention should, therefore, be determined by the following claims, with equivalents of the claims to be included therein.

WHAT IS CLAIMED IS:

1. An optics purge device comprising:
a purge device body including an optical port extending therethrough;
a purge gas inlet in the purge device body;
a primary distribution plenum in the purge device body and in fluid communication with the purge gas inlet;
a diffuser channel in the purge device body and in fluid communication with the primary distribution plenum, wherein the diffuser channel extends around the optical port; and
a diffuser accommodated within the diffuser channel.
2. The optics purge device of claim 1, wherein the diffuser is formed of a porous material.
3. The optics purge device of claim 1, wherein the diffuser has a generally annular shape.
4. The optics purge device of claim 1, wherein an outer sidewall of the diffuser includes an outer gland.
5. The optics purge device of claim 4, further comprising an outer sealing member held within the outer gland.
6. The optics purge device of claim 1, wherein an inner sidewall of the diffuser includes an inner gland.
7. The optics purge device of claim 6, further comprising an inner sealing member held within the inner gland.
8. The optics purge device of claim 1, wherein the diffuser channel extends around the optical port.
9. An optical assembly comprising:
an optics purge device including:
a purge device body having an optical port extending therethrough;
a purge gas inlet in the purge device body;
a primary distribution plenum in the purge device body and in fluid communication with the purge gas inlet;

a diffuser channel in the purge device body and in fluid communication with the primary distribution plenum; and

a diffuser accommodated within the diffuser channel;

an optical component mount configured to support an optical component; and

a sealing member disposed between the optics purge device and the optical component mount,

wherein a purge region is defined between the purge device body, the optical component mount and an optical component supportable by the optical component mount.

10. The optical assembly of claim 9, wherein the optical component includes a front optical surface and a rear optical surface.

11. The optical assembly of claim 10, wherein the front optical surface is exposed to the purge region.

12. The optical assembly of claim 11, wherein the purge region is in fluid communication with the optical port.

13. The optical assembly of claim 9, wherein the diffuser channel extends around the optical port.

14. The optical assembly of claim 9, further comprising the optical component.

15. The optical assembly of claim 9, wherein the optical component is a quarter-wave plate.

16. The optical assembly of claim 9, wherein the optical component is a mirror.

17. The optical assembly of claim 9, wherein the diffuser is formed of a porous material.