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(54) Title of the invention LIGHT SOURCE DEVICE

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SPECIFICATION

1. TITLE OF THE INVENTION

Light Source Device

2. SCOPE OF PATENT CLAIMS

1. A light source device comprising:

a gas-filled tube bulb;

a laser oscillator for excitation: and

an optical system device for focusing, onto the tube bulb, a laser beam from the laser emitting device:

configured so as to emit light through excitation of the filled gas in the tube bulb by the focused laser beam.

2. A light source device as set forth in Claim 1, wherein:

the filled gas is a gas a for emitting ultraviolet or deep ultraviolet light, such as a noble gas, halogen gas, argon gas, mercury vapor, or the like, where the tube bulb is structured from a material that transmits light in the ultraviolet or deep ultraviolet domain, such as calcium fluoride, lithium fluoride, magnesium fluoride, quartz glass, sapphire, or the like.

3. DETAILED EXPLANATION OF THE INVENTION

[FIELD OF USE OF THE INVENTION]

The present invention relates to a light source device, and, more particularly, relates to a light source device that is well suited as an ultraviolet/deep ultraviolet light source, in particular, for causing sealed gas to emit plasma through excitation with a laser beam.

[PRIOR ART]

In light source devices in semiconductor manufacturing equipment such as optical exposure devices, and the like, there are a variety of requirements, such as a long service life, stability of the position of the center of light emission, and the like, in addition to adequate strength of light emission add to the desired wavelength.

Conventionally, that which has been used as an ultraviolet or deep ultraviolet light source for photolithography has been of a type that produces an arc discharge between electrodes within a gas tube bulb that is filled with mercury gas or a noble gas (such as Xe gas, or the like), where because the electrodes are exposed to the arc discharge, they become extremely hot and gradually are vaporized, or are sputtered by high velocity electrons that are produced by the arc, and thus unavoidably the electrodes wear out, and the metal that is vaporized or produced through sputtering coats the inner wall surfaces of the tube bulb, and have an effect on the transparency for wavelengths in the ultraviolet domain, so that as time passes, the intensity and spectrum of the light emission changes gradually, and, at the same time, there are changes in the shape of the arc and changes in the position of the center of the light emission, due to the changes in the shape of the electrodes, and thus typically the service life is limited to several hundred hours, and thus it is necessary to stop the semiconductor manufacturing equipment frequently in order to change the tube bulb. Moreover, even when replacing the tube bulb, there are fine differences in the positions of the electrodes from bulb to bulb, requiring fine adjustments in the positions of the tube bulb each time a tube bulb is replaced.

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[OBJECT OF THE PRESENT INVENTION, AND SUMMARY THEREOF]

In order to solve the problem with the conventional technology, set forth above, the present invention provides a light source of device wherein there is little change over time in the intensity or spectrum of the light that is produced and wherein the position of the center of light emission is stabilized by an external optics system, wherein, through focusing a laser beam, from the outside, into a gas that is filled into a tube bulb, electrodischarge breakdown of the filled gas is produced through excitation by the laser beam, to cause the production of a high-temperature plasma of the filled gas at the focal position of the condensed laser beam within the tube, to produce a light source with a stabilized light emission intensity and the light emission central position with a spectral distribution that depends on the constituents of the filled gas.

In the light source device according to the present invention, there are no electrodes within the tube bulb, so there is no change in the intensity of light production nor in the spectrum due to the effects of evaporation or sputtering thereof, making it possible to produce a long service life, and, additionally, because the position of the center of the light emission is determined by the position of the focal point of the laser beam, it is always preserved with stability, and there is no change, even when the tube bulb is replaced. In the present invention, the spectral distribution of the light emission is determined by the composition of the filled gas, and when used in, for example, the ultraviolet or deep ultraviolet domain, a noble gas, such as Xe, a halogen gas, argon gas, mercury vapor, or the like, may be filled in a specific composition. Moreover, in this case, for the tube bulb itself, the material may be selected depending on the transparency in relation to the target wavelength domain, where, for example, calcium fluoride, lithium fluoride, magnesium fluoride, quartz glass, sapphire, or the like, may be used for ultraviolet or deep ultraviolet.

[EMBODIMENTS]

An embodiment of the present invention is provided as follows.

FIG. 1 is a structural diagram illustrating a basic structural example of a light source device according to the present embodiment, wherein a laser oscillator 1 emits a continuous or pulsed laser beam of an intensity that is adequate to excite electrodischarge of the filled gas. 2 and 3 are optical system elements for forming and projecting a laser beam in an appropriate shape for easy handling, where the projected laser beam is focused onto the position of the focal point within the tube bulb 5 by a focusing optical system element 4. The tube bulb 5 has deep ultraviolet radiation transparent material properties and is filled with, for example, a noble gas such as Xe, argon gas, mercury vapor, or the like, as a light-emitting gas. 6 is a reflective optical system element for reflecting again the laser beam that has passed through the tube bulb 5, and is conjugate with the focusing optical system element 4.

The laser beam from the laser oscillator 1 undergoes appropriate beam forming by the optical system elements 2 and 3 to pass through a specific light path to be focused onto a focal point position within the tube bulb 5, focused by the focusing optical system element 4. At the focal point that is determined in essentially the central position of the tube bulb 5, an electromagnetic field is produced with enough intensity to stimulate electrodischarge of the filled gas, through the strong energy of the laser beam, and a spectrum that includes ultraviolet and deep ultraviolet radiation is emitted from the high temperature plasma of the filled gas that is produced by the electrodischarge. In this case, the laser beam that has not contributed to the stimulation of the electrodischarge is incident into the reflecting optical system component 6, and is reflected thereby to be focused again onto the focal point of the tube bulb.

The light source device of the present invention is well-suited to semiconductor manufacturing equipment, in particular, due to the stability of the light emission intensity, spectrum, and central position of the light emission, where an example of application to exposure equipment is presented in FIG. 2 as a specific example of application thereof. In FIG. 2, those parts given the same symbols as in FIG. 1 have the same effects, where, additionally, 7 is an elliptical mirror for focusing, 8 is an illumination optical system device for the exposure equipment, 9 is a mask, and 10 is a wafer. When the deep ultraviolet radiation that is emitted from the tube bulb 5 is focused by the elliptical mirror 7 and projected onto the mask 9 by the illumination optics system device 8, the circuit patterns of the mask 9 are transferred onto the wafer 10, which has been coated with photoresist.

[EFFECTS OF THE INVENTION]

As described above, given the present invention, the sealed gas is excited by the laser beam within the tube bulb to undergo plasma emission of light, and thus there is no need to provide electrodes within the tube bulb, making it possible to solve all at once in the various problems with the conventional technology that have occurred due to the existence of the electrodes, making it possible to produce a light source device with a long service life wherein there is little change in the intensity of light produced or in the spectrum as time passes, where the position of the center of light emission is also determined by the

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position of the focal point of the external focusing optics system, regardless of the tube bulb, and so not only is always stable, but does not change, even when the tube bulb is replaced, making replacement of the tube bulb easy, and thus it is also easy to prepare tube bulbs with a variety of filled gases to make it possible to selectively obtain light sources for beams of different spectral distributions.

4. Brief Descriptions of the Drawings

FIG. 1 is a structural diagram illustrating one embodiment of the present invention, and FIG. 2 is a structural diagram illustrating an example of application to semiconductor manufacturing equipment.

1: Laser Oscillator
2, 3: Optical System Components
4: Focusing Optical System Component
5: Tube Bulb
6: Reflecting Optical System Element

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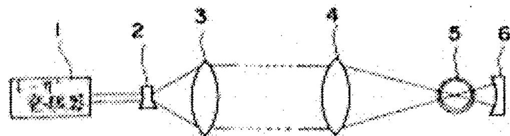
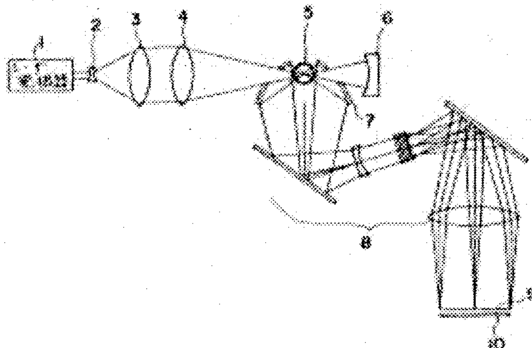
FIG. 1



1: Laser Oscillator

FIG. 2



1: Laser Oscillator

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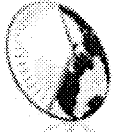
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To whom it may concern:

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㊹発明の名称　光源装置

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明　細　書

1．発明の名称

光源装置

2．特許請求の範囲

1．発光体としてのガス封入管球と、励起用レーザ発振装置と、該レーザ発振装置からのレーザ光を前記管球内に集光する光学系装置とを備え、集光されたレーザ光によって管球内の封入ガスを励起することにより発光させるようにしたことを特徴とする光源装置。

2．封入ガスが、希ガス、ハロゲンガス、アルゴンガス、水銀蒸気などの紫外ないし遠紫外発光用ガスであり、管球が、フッ化カルシウム、フッ化リチウム、フッ化マグネシウム、石英ガラス、サファイア等の紫外ないし遠紫外域の光を透過する材料で構成されていることを特徴とする特許請求の範囲第1項に記載の光源装置。

3．発明の詳細な説明

［発明の利用分野］

本発明は光源装置に関し、更に詳しくはレーザ

光による励起で封入ガスをプラズマ発光させる特に紫外・遠紫外光源として好適な光源装置に関する。

［従来技術］

露光装置などの半導体製造装置における光源装置には、所望波長域の発光強度が充分であることのほかに、寿命が長いことおよび発光中心の位置が安定していることなど、種々の要求がある。

従来、フォトリソグラフィ用の紫外ないし遠紫外光源として用いられていたのは、水銀蒸気或いは希ガス（Xeガス等）を封入したガラス管球内で電極間にアーク放電を発生させるタイプのものであり、電極がアーク放電に曝されるため極めて高温となって徐々に蒸発したり、またアークによって生じる高速粒子でスパッタされて電極が消耗したりするのが避けられず、これら蒸発ないしスパッタで生じた金属が管球内壁面に付着して紫外域の波長透過性を変化させるので、時間経過と共に発光強度とスペクトルとが徐々に変化し、同時に電極形状の変化によるアーク形状の変化と発光

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