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(54) Title: OPTICAL COMPONENT WITH BLOCKING SURFACE AND METHOD THEREOF

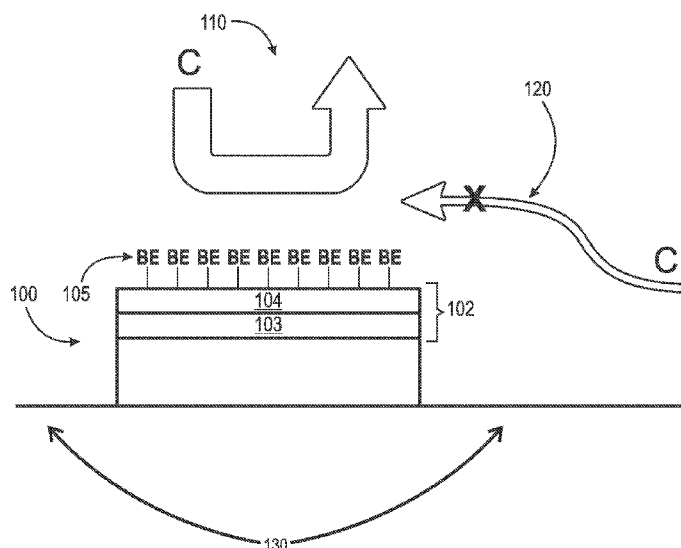


Fig. 1

(57) Abstract: An optical component arranged for use
in a low pressure environment including: a surface ar-
ranged to receive extreme ultra-violet (EUV) light and a
coating, on the surface, arranged to block at least one
contaminant in the low pressure environment from
binding to the surface. A method of mitigating contam-
ination of a surface of an optical component, including:
inserting the optical component into a chamber for a
semi-conductor inspection system, controlling a temper-
ature and a pressure within the chamber, introducing a
blocking material, in a gaseous state, into the chamber,
coating a surface of the optical component with the
blocking material, and preventing, using the coating, a
contaminant in the chamber from binding to the optical
component.



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OPTICAL COMPONENT WITH BLOCKING SURFACE AND METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit under 35 U.S.C. §119(e) of U.S. Provisional Patent Application No. 61/735,967, filed December 11, 2012, and under 35 U.S.C. §120 of U.S. Nonprovisional Patent Application No. 14/101,065, filed December 9, 2013, which applications are incorporated herein by reference.

STATEMENT REGARDING FEDERALLY SPONSORED
RESEARCH OR DEVELOPMENT

10 [0002] This invention was made under a CRADA (SC11/01785.00) between KLA-Tencor and Sandia Corporation, operated for the United States Department of Energy. The Government has certain rights in this invention.

TECHNICAL FIELD

[0003] The present disclosure relates to an optical component treated to prevent contamination of a surface of the component, a system including the component, and a method of coating an optical component with a contaminant-blocking surface. More particularly, the present disclosure relates to a surface of an optical component with a monolayer of atomic hydrogen or carbon-based molecules to prevent contaminants from adsorbing or diffusing onto the surface in a low pressure environment.

20 BACKGROUND ART

[0004] Figure 3 is a schematic side view of a prior art optical component showing possible routes of contamination. Extreme ultra-violent (EUV) light is used in semiconductor inspection and lithography systems. EUV light is absorbable by most materials, thus the materials surrounding the EUV light, for example, optic components, are vulnerable to contamination by way of carbonization and/or oxidation. Photon induced reactions from the EUV light can interact with contaminants, such as hydrocarbons and water, surrounding the EUV optics. Unfortunately, it is practically impossible to eliminate these contaminants. For example, a carbonization reaction with hydrocarbons can produce adsorbed hydrocarbons, which can produce a contaminant layer. Surfaces of optic components can become contaminated by two different routes. The first route is by adsorption from the gas-phase. A second route of contamination is by surface diffusion by hydrocarbon species that have adsorbed onto hardware surrounding the optical components.

30 [0005] The two contamination routes described above can also occur when the semiconductor inspection lithography system is vented to atmosphere for routine maintenance. In

some cases, the venting atmosphere may be contaminated, or turbo pumps used in the venting have collected contaminants as the venting gas pass into the tool being vented. Alternatively, contaminant species may be stirred-up by the venting process, and inadvertently deposited onto component surfaces.

5 [0006] Figure 3 shows a typical unprotected optical component 300. Contaminants C from contamination 310 and 320 create contaminant layer 303, which degrades the reflectivity of optical component 300. Contamination 310 refers to contaminants C, for example, hydrocarbons, in a residual vacuum, which tend to adsorb onto optical components from the gas-phase. Contamination 320 refers to contaminants C, for example, hydrocarbons,
10 which tend to diffuse onto surface 302 from surrounding hardware 330, which is in contact with optical component 300.

[0007] Others have recognized this problem. It has been suggested that contamination can be reduced by simply reducing the residual water vapor and hydrocarbons present however, such a solution has proven to be very difficult, if not impossible, to achieve.
15 U.S. Patent No. 6,533,952 (Klebanoff *et al.*) describes a process for mitigating or eliminating contamination and/or degradation of surfaces having common, adventitious atmospheric contaminants adsorbed thereon and exposed to radiation. A gas or a mixture of gases is introduced into the environment of a surface to be protected. When the surface and associated bound species are exposed to radiation, reactive species are formed that react with surface
20 contaminants such as carbon or oxide films to form volatile products (*e.g.*, carbon monoxide and carbon dioxide) which desorb from the surface.

[0008] U.S. Patent No. 6,770,776 (Klebanoff *et al.*) describes an apparatus that produces activated gaseous species adjacent a surface that is subject to carbon contamination such that in-situ cleaning of that surface is permitted.

25 DISCLOSURE OF INVENTION

[0009] According to aspects illustrated herein, there is provided an optical component arranged for use in a low pressure environment, including a surface arranged to receive extreme ultra-violet (EUV) light and a coating, on the surface, arranged to block at least one contaminant in the low pressure environment from binding to the surface.

30 [0010] According to aspects illustrated herein, there is provided a semi-conductor inspection system including a low pressure chamber, an inspection assembly in the low pressure chamber including an optical component with a surface arranged to receive extreme

ultra-violet (EUV) light and a coating, on the surface, arranged to block a contaminant in the low pressure chamber from binding to the surface.

[0011] According to aspects illustrated herein, there is provided a method of mitigating contamination of a surface of an optical component, including: inserting the optical component into a chamber for a semi-conductor inspection system, controlling a temperature and a pressure within the chamber, introducing a blocking material, in a gaseous state, into the chamber, coating a surface of the optical component with the blocking material, and preventing, using the coating, a contaminant in the chamber from binding to the optical component.

[0012] According to aspects illustrated herein, there is provided a method of mitigating contamination of a surface of an optical component, including: inserting the optical component into a chamber, controlling a temperature and a pressure within the chamber, introducing molecular hydrogen into the chamber, disassociating the molecular hydrogen into hydrogen atoms, and coating a surface of the optical component with a monolayer of the hydrogen atoms. Substantially all of the orbitals for the hydrogen atoms are unavailable for bonding.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Various embodiments are disclosed, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, in which:

Figure 1 is a schematic side view of an optical component with a contaminant-blocking coating;

Figure 2 is a schematic block diagram of a semi-conductor inspection system including the optical component shown in Figure 1; and,

Figure 3 is a schematic side view of a prior art optical component showing possible routes of contamination.

BEST MODE FOR CARRYING OUT THE INVENTION

[0014] At the outset, it should be appreciated that like drawing numbers on different drawing views identify identical, or functionally similar, structural elements of the disclosure.

It is to be understood that the disclosure as claimed is not limited to the disclosed aspects.

[0015] Furthermore, it is understood that this disclosure is not limited to the particular methodology, materials and modifications described and as such may, of course, vary. It is

also understood that the terminology used herein is for the purpose of describing particular aspects only, and is not intended to limit the scope of the present disclosure.

[0016] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this disclosure belongs. It should be understood that any methods, devices or materials similar or equivalent to those described herein can be used in the practice or testing of the disclosure. The term “coating” is used interchangeably with the term “monolayer”. Additionally, the term “enclosed space” is used synonymously with the term “chamber”. The terms “material” and “elements” are used synonymously.

[0017] Figure 1 is a schematic side view of optical component **100** with a contaminant-blocking coating. Optical component **100** includes surface **102** and contaminant-blocking coating **105**. Optical component **100** is arranged for use in a low pressure environment and surface **102** is arranged to receive extreme ultra-violet (EUV) light in the low pressure environment, as further described below. Coating **105**, on surface **102**, is arranged to block at least one contaminant **C**, also shown as **110** and **120**, in the low pressure environment from binding to surface **102**. Optical component **100** can be any optical component known in the art, including, but not limited to a mask, a mirror, a silicon wafer, or a sensor.

[0018] Layer **102** includes orbitals available for bonding. Thus, if contaminants **C** were to approach unprotected (uncoated) layer **102**, the contaminants would be attracted to layer **102** and would strongly bond to layer **102**, as is the case in Figure 3. However, substantially all of the orbitals of coating **105** are unavailable for bonding. Thus, coating **105** resists strong bonds with contaminants, blocking the contaminants from binding to surface **102**.

[0019] In an example embodiment, coating **105** is a layer of adsorbed hydrogen atoms one atom deep. In an example embodiment, surface **102** includes layer **103** of metal. In an example embodiment, surface **102** includes layer **104** of an oxide of the metal in layer **103**. It should be appreciated that Figure 1 is a schematic representation of how coating **105** monopolizes the surface sites of surface **102** to block contaminants **C** from binding to surface **102**. Metal **103** can be any metal known in the art, for example, Ruthenium (Ru). In an example embodiment, **BE** is atomic hydrogen. Atomic hydrogen refers to isolated hydrogen atoms. Coating **105** with atomic hydrogen can be generated by introducing molecular hydrogen, meaning molecules of hydrogen or hydrogen atoms bound together, into the

vicinity of component **100**. The metal in layer **103** causes the hydrogen to disassociate into atomic hydrogen, which then bonds to surface **102** to form coating **105**. Coating **105** is also referred to interchangeably herein as monolayer **105**.

[0020] In an example embodiment, the formation of coating **105** is effected at
5 cryogenic temperatures (~150K). Hydrogen has a low EUV absorption such that the monolayer layer of hydrogen will not harm optical component **100**.

[0021] In another example embodiment, coating **105** is formed of material having a low EUV absorption. Thus, coating **105** can include a layer of carbon monoxide one molecule deep, a layer of carbon dioxide one molecule deep, or a layer of TSurface CO_3^{-2}
10 anions one anion deep.

[0022] It should be appreciated that surface **102** of optical component **100** has an optical characteristic prior to application of coating **105** and the optical characteristic is not affected by coating **105**. In an example embodiment, the optical characteristic is reflectivity of EUV light. However, it should be appreciated that the optical characteristic could be any
15 optical characteristic known in the art, for example, diffraction, dispersion, polarization, or absorption.

[0023] Figure 2 is a schematic block diagram of semi-conductor inspection system **200** including optical component **100** shown in Figure 1. The following should be viewed in light of Figures 1 and 2. Semi-conductor inspection system **200** includes extreme ultra-violet
20 EUV light source **201** arranged to transmit light to inspection assembly **202**, low pressure chamber **206**, and inspection assembly **204** in low pressure chamber **206**. Optical component **100** is located in assembly **204**. The discussion of optical component **100** in Figure 1 is applicable to system **200** except as noted. Coating **105** is arranged to block at least one contaminant in low pressure chamber **206** from binding to surface **102**. With sufficient
25 exposure to contaminants, blocking elements **BE** can become reactive; therefore, as further described below, blocking elements **BE** are maintained at a rate sufficient to continue to prevent contaminants **C** from absorbing to layer **102**. In an example embodiment, inspection assembly **202** includes mask **203**, inspector or wafer **207**, and vacuum pump **205**.

[0024] In an example embodiment, optical component **100** is fabricated by inserting
30 optical component **100** having surface **102** into an enclosed space, such as chamber **206**. Pressure and temperature are controlled within chamber **206** and blocking element (or material) **BE**, is introduced, in a gaseous state, into the chamber. As described above, element **BE** bonds with surface **102**, forming coating **105**. In an example embodiment, **BE** is

molecular hydrogen. As noted above, coating **105** of atomic hydrogen is formed from the molecular hydrogen.

[0025] In an example embodiment, controlling the pressure includes maintaining a pressure of approximately 1 to 50 milliTorr in the chamber. However, it should be appreciated that any suitable pressure is applicable. In an example embodiment, controlling the temperature includes maintaining a temperature of between 288 and 308 degrees Kelvin. In an example embodiment, controlling the temperature includes maintaining cryogenic temperatures, for example, below 150 degrees Kelvin. However, it should be appreciated that the necessary temperature depends on blocking element **BE** of coating **105**, for example, hydrogen, carbon monoxide, or carbon dioxide. Similarly, the necessary pressure also depends on blocking element **BE** of coating **105**.

[0026] In an example embodiment, a layer of molecular hydrogen is maintained above surface **102**, for example, to regenerate coating **105** as the atomic hydrogen forming coating **105** becomes reactive. For example, monolayer **105** is created and maintained at room temperature by keeping an elevated pressure (1-50 milliTorr) of **BE**, for example, hydrogen, above surface **102** during system operation to maintain a full monolayer **105** of hydrogen atoms on surface **102**.

[0027] In an example embodiment, prior to venting system **200**, system **200** is flushed briefly with hydrogen, for example, at elevated pressures (100-500 milliTorr) to further ensure the presence of monolayer **105** on surface **102** during the venting process during which contamination of surface **102** is more likely to occur. Further, flushing can be used to treat contaminated surfaces. In this manner, if surface **102** is contaminated, surface **102** can be flushed with purified carbon dioxide or carbon trioxide, followed by purified hydrogen. Carbon monoxide or other gases, such as, oxides (N_xO_y), are also suitable.

[0028] In example embodiment, chamber **206** is flushed with molecular hydrogen at a pressure of approximately 100 to 500 milliTorr and chamber **206** is then vented. When system **200** is vented, adsorbed hydrogen in coating **105** reduces the inadvertent contamination of the critical surfaces from contaminants **C** that may be in the venting gas, thereby preserving the optical integrity during the maintenance periods.

[0029] In an example embodiment, surface **102** is periodically dosed with blocking element **BE** to maintain coating **105**. In an example embodiment, prior to introducing blocking element **BE** into chamber **206**, metal oxide from surface **102** is removed using some

or all of atomic hydrogen, molecular hydrogen, extreme ultra-violet light, and carbon monoxide.

[0030] In an example embodiment, optical component **100** is a multi-layer collector mirror (MLM) and helium (He) is introduced into the chamber **206** to prevent damage during operation and contamination during venting. In an example embodiment, the multi-layer collector mirror is biased and an electric field surrounding the multi-layer collector mirror is generated. In an example embodiment, the multi-layer collector is biased using an oscillating voltage.

[0031] In an example embodiment, surface **102** can be protected by exposing surface **102** to low energy helium ions and neutrals prior to use in EUV systems. It is beneficial to expose MLM surfaces to carbon monoxide, carbon trioxide, and helium prior to vacuum vents. The goal of these exposures is to prevent damage during operation and contamination during venting. The MLMs can be biased such that an electric field can be created between the MLM and the surrounding surfaces and incoming gas-phase species, thereby allowing for the effective energy of incoming ions to be increased. Biasing of these surfaces may also allow or prevent attachment of anion and/or cation species presented near the surface. Biasing of these surfaces by an oscillating voltage may be used to increase the desired effect.

[0032] In an example embodiment, surface **102** is dosed as needed with short bursts of carbon monoxide gas during tool operation, or briefly exposed to a flush of carbon monoxide prior to venting. After surface **102** is passivated by carbon monoxide, a monolayer **105** of carbon monoxide is formed without adversely affecting optical performance. Other gases can perform this function, for example, carbon dioxide, carbon trioxide, or polar molecules. When polar molecules are used, it is advantageous to place an opposite charge on surface **102** prior to venting.

[0033] Surface **102** can be preconditioned to enhance passivation. For example, on Ru surfaces one can use atomic hydrogen and EUV + H₂ to remove Ru oxides. Thus, starting with a virgin Ru surface will create enough surface sites to allow carbon monoxide passivation before venting. Carbon monoxide may passivate a clean Ru surface more completely than an oxide surface. In this case, it might be advantageous to precondition the Ru surface prior to carbon monoxide exposure. Similar arguments may apply for carbon or other contaminants on surface **102**.

[0034] As noted above, carbon dioxide or carbon trioxide may be used as blocking element **BE**; carbon trioxide is known in the art to exist as anions when absorbed on alkali

and transition metal surfaces. TSurface CO_3^{-2} anions can act as surface blocking agents to prevent the absorption of contamination on the surface during venting, and as cleaning agent during system vacuum recovery after venting. An effective method of generating surface CO_3^{-2} anions is to predose surface **102** (mirror capping layer could be material such as Ru but, the layer is not limited to Ru) with atomic oxygen followed by carbon dioxide. Other methods to generate CO_3^{-2} anion could be $\text{CO} + \text{CO}_2$ co-venting and $\text{O}_2 + \text{CO}_2$ co-venting.

[0035] Extreme EUV light of emerging inspection systems can involve MLMs made of Molybdenum/Silicon (Mo/Si). As is known in the art, MLMs are exposed to impinging fast ions, water, oxygen, contaminant species as well as impurities and debris leading to the degradation of optical system components. At moderate ion fluences ($\sim 10^{14} \text{ Xe}^+/\text{cm}^2$), reflectivity loss occurs and very high fluences ($> 10^{17} \text{ Xe}^+/\text{cm}^2$) samples have shown signs of Xe blisters formation. Blistering has additionally been witnessed on Mo/Si multilayers as a result of irradiation by hydrogen species generated in a thermal capillary cracker. Blistering has also been attributed to oxygen, and water, or other contaminant species. Low-energy deuterium (D) plasma exposure on tungsten (W), which is an important material for fusion materials, results in blister formation on surface **102**, for example, on MLMs. Blister formation increases both micron-sized dust production and D retention. Blister formation depends greatly on pretreatment of surface **102**. Experiments have shown that a dramatic decrease in the retention properties of W when even a small amount of helium is present in the plasma. Proximate surface **102**, helium filled nano-bubbles may act as a diffusion barrier to hydrogen isotopes. Helium may also reduce hydrogen isotope permeation.

[0036] It should be appreciated that a plurality of optical components is contemplated in a single system. Furthermore, it should be appreciated that optical component **100** does not experience over-doing of coating **105**. Coating **105** includes molecules, for example, hydrogen or carbon monoxide that cannot grow as multilayers on an optic surface at room temperature. Advantageously, coating **105** is a monolayer to prevent the risk of over-dosing the optic component, which would harm reflectivity. Additionally, it should be appreciated that blocking element **BE** is introduced into the chamber via any suitable input mechanism **208**.

[0037] It will be appreciated that various of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives,

modifications, variations, or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

CLAIMS

What Is Claimed Is:

1. An optical component arranged for use in a low pressure environment, comprising:
a surface arranged to receive extreme ultra-violet (EUV) light; and,
5 a coating, on the surface, arranged to block at least one contaminant in the low pressure environment from binding to the surface.
2. The optical component recited in Claim 1, wherein the coating is a layer of adsorbed hydrogen atoms one atom deep.
- 10 3. The optical component recited in Claim 1, wherein substantially all of the orbitals for the coating are unavailable for bonding to other substances.
4. The optical component recited in Claim 1, wherein the coating is selected from the
15 group consisting of a layer of adsorbed carbon monoxide molecules one molecule deep, a layer of adsorbed carbon dioxide molecules one molecule deep, and a layer of TSurface CO_3^{2-} anions one anion deep.
5. The optical component recited in Claim 1, wherein the coating prevents the
20 contaminant from:
adsorbing onto the surface; or,
diffusing onto the surface.
6. The optical component recited in Claim 1, wherein:
25 the surface has an optical characteristic prior to application of the coating; and,
the optical characteristic is not affected by the coating.
7. The optical component recited in Claim 1, wherein the surface includes a metal oxide.
8. The optical component recited in Claim 1, wherein the optical component is selected
30 from the group consisting of a mask, a mirror, a silicon wafer, and a sensor.
9. A semi-conductor inspection system, comprising:
a low pressure chamber;

an inspection assembly, in the low pressure chamber, including:

an optical component with:

a surface arranged to receive extreme ultra-violet (EUV) light; and,

5 a coating, on the surface, arranged to block a contaminant in the low pressure chamber from binding to the surface.

10 10. The system of Claim 9, further comprising:

a plasma source arranged to generate the EUV light.

11. The system recited in Claim 9, wherein substantially all of the orbitals for the coating are unavailable for bonding to other substances.

12. The system of Claim 9, wherein the coating is a layer of adsorbed hydrogen atoms one atom deep.

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13. The system of Claim 9, wherein the coating is selected from the group consisting of a layer of adsorbed carbon monoxide molecules one molecule deep, a layer of adsorbed carbon dioxide molecules one molecule deep, and a layer of TSurface CO_3^{-2} anions one anion deep.

20 14. The system of Claim 9, wherein the coating prevents the contaminant from: adsorbing onto the surface; or, diffusing onto the surface.

15. The system of Claim 9, wherein the optical component is selected from the group consisting of a mask, a mirror, a silicon wafer, and a sensor.

25

16. A method of mitigating contamination of a surface of an optical component, comprising:

30 inserting the optical component into a chamber for a semi-conductor inspection system;

controlling a temperature and a pressure within the chamber;

introducing a blocking material, in a gaseous state, into the chamber;

coating a surface of the optical component with the blocking material; and,

preventing, using the coating, a contaminant in the chamber from binding to the optical component.

17. The method recited in Claim 16, wherein preventing the contaminant in the chamber
5 from binding to the optical component includes preventing the contamination from:
adsorbing onto the surface; or,
diffusing onto the surface.

18. The method recited in Claim 16, wherein preventing the contaminant in the chamber
10 from binding to the optical component includes rendering substantially all of the orbitals for
the coating unavailable for bonding to other substances.

19. The method recited in Claim 16, wherein controlling the pressure includes
maintaining a pressure of approximately 1 to 50 milliTorr in the chamber.
15

20. The method recited in Claim 16, wherein controlling the temperature includes
maintaining a temperature of between 288 and 308 degrees Kelvin in the chamber.

21. The method recited in Claim 16, wherein introducing a blocking material includes
20 introducing molecular hydrogen into the chamber.

22. The method recited in Claim 21, wherein introducing molecular hydrogen into the
chamber includes maintaining a layer of molecular hydrogen above the surface.

25 23. The method recited in Claim 21, wherein:
the surface is formed of a metal oxide; and,
coating the surface of the optical component includes:
disassociating the molecular hydrogen into hydrogen atoms; and,
binding a layer of hydrogen atoms, one atom deep, onto the surface.

30 24. The method recited in Claim 16, further comprising:
flushing the chamber with molecular hydrogen at a pressure of approximately 100 to

500 milliTorr; and,
venting the chamber.

25. The method recited in Claim 16, wherein introducing the blocking material includes
5 periodically dosing the surface with the blocking material.

26. The method recited in Claim 16, wherein introducing the blocking material includes
introducing a material selected from the group consisting of carbon monoxide, carbon
dioxide, carbon trioxide, and polar molecules.

10

27. The method recited in Claim 26, wherein the polar molecules have a first charge, the
method further comprising:
applying a second charge, opposite the first charge, to the optical component.

15 28. The method recited in Claim 16, wherein the surface is formed by a metal, the method
further comprising:
prior to introducing the blocking element, removing metal oxide from the surface
using some or all of atomic hydrogen, molecular hydrogen, extreme ultra-violet light, or
carbon monoxide.

20

29. The method recited in Claim 16, wherein:
the optical component is a multi-layer collector mirror; and,
introducing the blocking element includes introducing helium into the chamber.

25 30. The method recited in Claim 29, further comprising:
biasing the multi-layer collector mirror; and,
generating an electric field surrounding the multi-layer collector mirror.

31. The method recited in Claim 30, wherein biasing the multi-layer collector mirror
30 includes biasing the multi-layer collector using an oscillating voltage.

32. A method of mitigating contamination of a surface of an optical component,
comprising:

- inserting the optical component into a chamber;
controlling a temperature and a pressure within the chamber;
introducing molecular hydrogen into the chamber;
disassociating the molecular hydrogen into hydrogen atoms; and,
5 coating a surface of the optical component with a monolayer of the hydrogen atoms,
wherein substantially all of the orbitals for the hydrogen atoms are unavailable for bonding.

33. The method recited in Claim 32, wherein introducing molecular hydrogen into the chamber includes maintaining a layer of molecular hydrogen above the surface.

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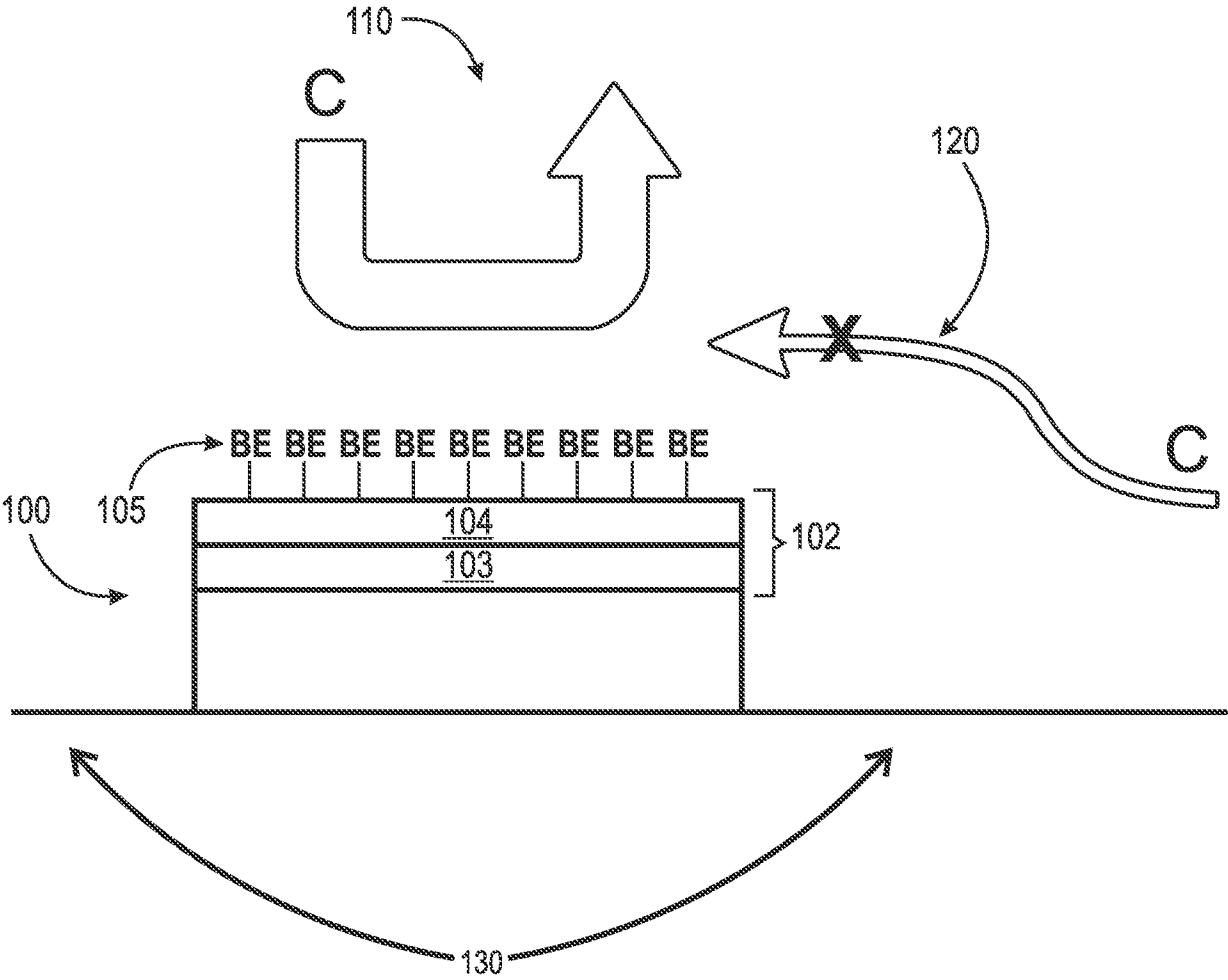


Fig. 1

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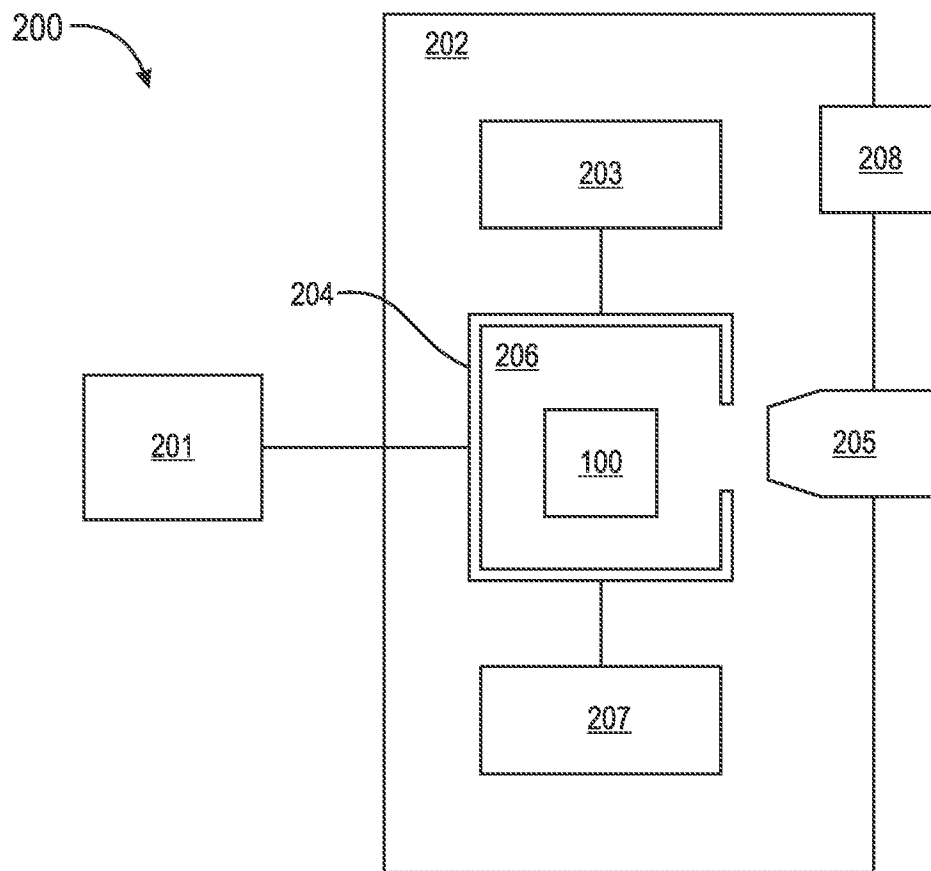
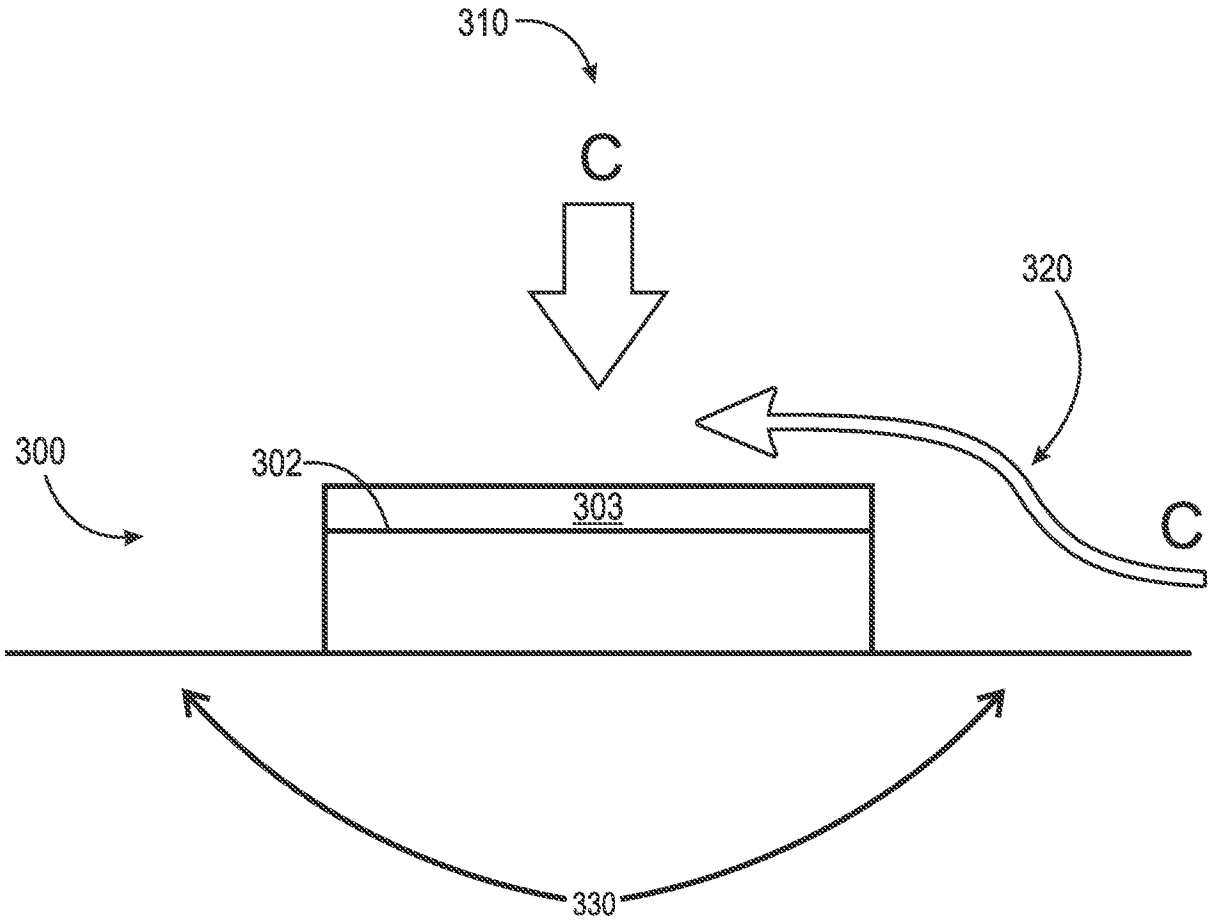


Fig. 2



PRIOR ART

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/074146**A. CLASSIFICATION OF SUBJECT MATTER****G02B 1/10(2006.01)i, G01N 21/33(2006.01)i, H01L 21/027(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G02B 1/10; B32B 9/00; G03F 1/00; G21G 5/00; H01L 31/12; B08B 3/12; G03C 5/00; G11B 5/127; H01L 21/00; G01N 21/33; H01L 21/027

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: hydrogen monolayer, atomic hydrogen, contamination, oxidation, and EUV

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7763399 B2 (SENGUPTA et al.) 27 July 2010 See abstract; column 3, line 5-column 4, line 55; column 5, line 8-column 7, line 10; claims 1-7 and figures 1,2,4.	1-3, 5-12, 14-25, 28 , 32, 33
A		4, 13, 26, 27, 29-31
A	US 2002-0084425 A1 (KLEBANOFF et al.) 04 July 2002 See abstract; paragraphs 17-22 and figure 2.	1-33
A	US 2006-0127780 A1 (CHANDHOK et al.) 15 June 2006 See abstract; paragraphs 9-15 and figure 3.	1-33
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Further documents are listed in the continuation of Box C.



See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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