



- (51) **International Patent Classification:**
H05H 1/00 (2006.01) *H01J 17/30* (2006.01)
- (21) **International Application Number:** PCT/US2015/058650
- (22) **International Filing Date:** 2 November 2015 (02.11.2015)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
62/074,001 1 November 2014 (01.11.2014) US
14/739,305 15 June 2015 (15.06.2015) US
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- (81) **Designated States** (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) **Designated States** (*unless otherwise indicated, for every
kind of regional protection available*): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,

[Continued on next page]

(54) **Title:** APPARATUS AND METHODS FOR OPTICS PROTECTION FROM DEBRIS IN PLASMA-BASED LIGHT SOURCE

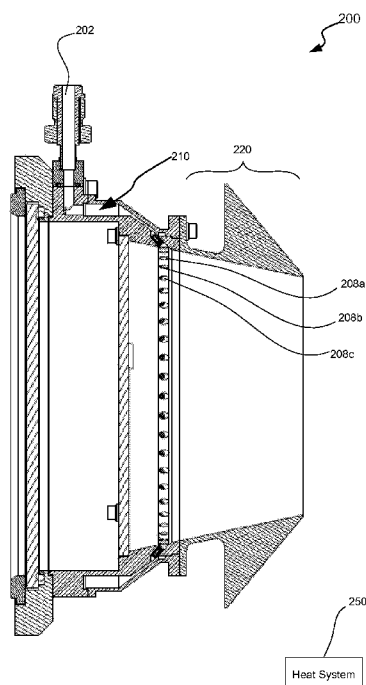


Figure 2B

(57) **Abstract:** Disclosed are methods and apparatus for generating an illumination beam. In one embodiment, the apparatus includes a vacuum chamber configured to hold a target material, an optical element positioned within the vacuum chamber or within a wall of such vacuum chamber, and an illumination source system for generating at least one excitation source that is focused on the target in the vacuum chamber for generating a plasma in the vacuum chamber so as to produce illumination radiation. The apparatus further includes a debris protection system for flowing gas out of a plurality of nozzles and away from the optical element at a velocity towards the plasma so as to prevent debris from reaching such optical element.



TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

Apparatus and Methods for Optics Protection from Debris in Plasma-Based Light Source

CROSS-REFERENCE TO RELATED APPLICATION

5 **[0001]** This application claims priority of U.S. Provisional Patent Application Number 62/074,001, entitled "Method and Apparatus to Protect Internal Optical Elements for LPP EUV Source, filed 1 November 2014 by Ye Liu et al., which application is herein incorporated by reference in its entirety for all purposes.

10 TECHNICAL FIELD OF THE INVENTION

[0002] The invention generally relates to the field of plasma-based illumination source systems, especially in the context of reticle inspection. More particularly the present invention relates to apparatus and techniques for protecting illumination source elements from debris generated in such plasma-based
15 illumination source system.

BACKGROUND

[0003] Plasma-based illumination source systems, such as laser-produced plasma (LPP) sources, laser-sustained plasma (LSP) sources, laser-driven light
20 sources (LDLS), or discharge-produced plasma (DPP) sources, are often used to generate soft x-ray, extreme ultraviolet (EUV), and vacuum ultraviolet (VUV) wavelengths of illumination (e.g. wavelengths around 120 nm or shorter) for applications such as defect inspection, photolithography, or metrology. The illumination may be emitted by a plasma that is generated at or near a site where
25 target material (e.g. xenon, tin, or lithium) is deposited and irradiated by an

excitation source, such as a laser. Illumination emanating from the plasma may be collected and directed and/or focused along an illumination delivery path.

[0004] Plasma-based light sources, such as EUV, used for lithography, mask inspection and metrology also suffer from debris generated as a by-product of the plasma formation process, which can include high energy ions and neutrals, atomic clusters, condensable vapor, particles, etc. These undesired by-products can cause serious damage and shorten lifetime of optical elements placed inside the EUV source vacuum chamber, e.g., laser entrance window, EUV collector, metrology windows and mirrors, detectors, etc.

[0005] There is a continuing need for improved mechanisms for protecting illumination source elements in plasma-based illumination generation or source systems from debris.

SUMMARY

[0006] The following presents a simplified summary of the disclosure in order to provide a basic understanding of certain embodiments of the invention. This summary is not an extensive overview of the disclosure and it does not identify key/critical elements of the invention or delineate the scope of the invention. Its sole purpose is to present some concepts disclosed herein in a simplified form as a prelude to the more detailed description that is presented later.

[0007] In one embodiment, a plasma-based illumination apparatus for generating radiation is disclosed. The apparatus includes a vacuum chamber configured to hold a target material, an optical element positioned within the vacuum chamber or within a wall of such vacuum chamber, an illumination source system for generating at least one excitation source that is focused on the target in the vacuum chamber for generating a plasma in the vacuum chamber so as to produce illumination radiation, a collector system for collecting and directing the produced illumination radiation towards a sample. The apparatus further includes a debris protection system for flowing gas out of a plurality of nozzles and away from the optical element at a velocity towards the plasma so as to

prevent debris from reaching such optical element resulting in a Peclet number averaged over a protected area of the optical element that is greater than or equal to 2. In other embodiments, the resulting Peclet number that is averaged over a protected area is greater than or equal to 4.

5 **[0008]** In a specific implementation, the produced radiation has an extreme ultraviolet (EUV) wavelength range that is equal to or less than 13.5 nm and the gas transmits EUV light. In a further aspect, the optical element is an entrance window of the chamber that is positioned between about 0.1 to 2.5 meters from the target material. In another aspect, the optical element is a collector element,
10 a metrology window, a filter, a deflector, or a mirror.

[0009] In another aspect, an area occupied by a plurality of openings of the nozzles is smaller than a surface area of the optical element. In yet another aspect, a flow rate of the gas is less than 20 standard liters per minute (slm). In a specific embodiment, the gas comprises one or more of the following gases: Ar,
15 H₂, He, Br₂, HBr, or N₂. In another aspect, each nozzle has a circular hole and the plurality of nozzles are arranged to produce a uniform gas stream, a planar gas curtain, or a ring-shaped jet. In another implementation, the debris protection system further comprises a manifold fluidly coupled between the nozzles and a gas source or gas inlet, and the manifold has a higher gas conductance than all
20 the nozzles combined. In a further aspect, the debris protection system includes a gas cone for directing the gas towards the plasma or another debris source. In a specific implementation, the nozzles are evenly distributed. In another aspect, the nozzles have a count and/or size and/or temperature that is selected by a computational fluid dynamics simulation to provide a predefined level of optics
25 protection and to avoid gas condensation.

[0010] In another feature, the apparatus includes a pellicle positioned in front of the optical element. In another embodiment, the optical element is an entrance window in the wall of the vacuum chamber through which the focused excitation source is received. In a further aspect, the apparatus includes a pellicle

positioned between the optical element and a source of debris, and the pellicle and/or entrance window are comprised of a sapphire material.

[0011] In yet another implementation, the apparatus includes an expansion stage fluidly coupled between each nozzle and the vacuum chamber, and the expansion stage for each nozzle has a diameter larger than a diameter of such nozzle and smaller than a diameter of the vacuum chamber. In another aspect, the apparatus includes a baffle positioned downstream of each nozzle. In yet another example implementation, the apparatus includes a heating system for increasing a temperature of each nozzle to prevent condensation of the gas at each nozzle's exit.

[0012] In an alternative embodiment, the invention pertains to an inspection system for inspecting a photolithographic reticle or wafer for defects, and the sample is a wafer or reticle. The system comprises an apparatus for generating the illumination beam and having any one or more of the above-recited features.

This system further includes imaging optics for directing the illumination radiation towards the reticle or wafer, a detector for receiving a detected signal or image from the reticle or sample in response to the illumination radiation being directed to the reticle or wafer, and a processor and memory that are configured to analyze the detected signal or image to thereby detect defects on the reticle or wafer.

[0013] In another embodiment, the invention pertains to a photolithography system for transferring a pattern from a reticle onto a wafer. This system includes an apparatus for generating the illumination beam and having one or more of the above-recited features. The system also includes imaging optics for directing the illumination radiation via a reticle onto a wafer.

[0014] These and other aspects of the invention are described further below with reference to the figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Figure 1A is a diagrammatic representation of a plasma-based illumination source system with a debris mitigation mechanism in accordance with one embodiment of the present invention.

5 **[0016]** Figure 1B is a diagrammatic representation of a plasma-based illumination source system with a debris mitigation mechanism in accordance with an alternative embodiment of the present invention.

[0017] Figure 2A is a perspective view of a gas injection system in accordance with a specific implementation of the present invention.

10 **[0018]** Figure 2B is a side view perspective of the gas injection system of Figure 2A.

[0019] Figure 3 illustrates a cross section of gas flow distribution through 48 gas nozzles to form a protected flow in accordance with one embodiment of the present invention.

15 **[0020]** Figure 4A and 4B show the results of a CFD (computational fluid dynamics) simulation for flowing argon from a high-pressure reservoir, through 12 tubes, each with a diameter of 0.75 mm and length of 3.2 mm, into a low pressure vacuum chamber.

20 **[0021]** Figure 5 shows that state of the argon, in pressure-temperature (p-T) space, for a path along the centerline of the geometry that is shown in Figures 4A and 4B, starting from the reservoir and ending in the vacuum chamber.

[0022] Figure 6A and 6B show the results of a CFD simulation for a debris protection system having an increase in nozzle count from 12 to 60.

25 **[0023]** Figure 7 shows the state of an argon flow in p-T space for a debris protection system having 12, 48 and 60 tubes.

[0024] Figure 8 shows the results of a CFD simulation for a debris protection system having an increased tube diameter of 3.5 mm.

[0025] Figure 9 shows the state of an argon flow in p-T space for a debris protection system having a tube diameter of 3.5 mm.

[0026] Figure 10A shows the result of a CFD simulation for a debris protection system having 48 tubes.

5 **[0027]** Figure 10B shows the result of a CFD simulation for a debris protection system having 48 tubes and an intermediate stage.

[0028] Figure 11 shows the effect of a second stage on the state of an argon flow in p-T space.

10 **[0029]** Figure 12 shows the results of a CFD simulation for a design having a baffle plate with a diameter of 2.4 mm and located 1 mm downstream of the tube outlet.

[0030] Figure 13 shows the effect of using a baffle plate on the argon state in p-T space.

[0031] Figure 14 shows the effect of tube temperature on the state of the argon.

15 **[0032]** Figure 15 provides a schematic representation of an inspection apparatus in accordance with certain embodiments.

[0033] Figure 16 is a simplified schematic representation of a lithographic system for transferring a mask pattern from a photomask onto a wafer in accordance with certain embodiments.

20 **[0034]** Figure 17 is a flow chart illustrating a debris protection procedure in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

25 **[0035]** In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. The present invention may be practiced without some or all of these specific details. In other

instances, well known component or process operations have not been described in detail to not unnecessarily obscure the present invention. While the invention will be described in conjunction with the specific embodiments, it will be understood that it is not intended to limit the invention to the embodiments.

5 **[0036]** Figure 1A is a diagrammatic representation of a plasma-based illumination source system 100 with a debris mitigation mechanism in accordance with one embodiment of the present invention. By way of example, the illumination source system may utilize laser-produced plasma soft x-ray, EUV, or VUV illumination source. As shown, the illumination source system may include one or more
10 excitation sources 102, such as a drive laser, arranged to irradiate a target material 108 with beam 104. Alternatively, in a discharge-produced plasma source (not shown), the excitation source may include, but is not limited to, coils configured to magnetically excite the target material. In an embodiment, the excitation source 102 is configured to irradiate the target material 108 with a
15 beam of illumination or a train of light pulses (e.g., 104) delivered into a cavity defined by a vacuum chamber 107. The illumination 104 emanating from the excitation source 102 may be directed through an entrance window 106 of the vacuum chamber 107.

[0037] During operation of a plasma-based illumination source system, debris
20 such as atomic vapor, micro-particles, or contaminants (e.g. hydrocarbons or organics) may be emitted from various sources including, but not limited to, the target material, plasma site, plasma-facing components, eroded surfaces in proximity of the target material or the plasma, a target-forming structure, and/or any other structure within a plasma-based illumination source system. Debris can
25 sometimes reach the reflective optical elements and degrade their performance or cause irreparable damage.

[0038] Contamination of the laser input window or other optical elements not only leads to reduction of the laser energy due to loss of transmission, but also degrades the laser beam quality and ability to focus, resulting in lower EUV
30 output and distorted EUV source beam shape.

[0039] Some methods of protecting the reflective optic include deflection of debris by magnetic fields, removal by chemical etchants, or stopping by debris vanes or shields that are configured to allow soft x-ray, EUV, or VUV light to go through while capturing the atomic condensable vapor, and a gas buffer region that is generated between the target and the collector or laser window. Each of the foregoing methods has some drawbacks, as outlined below.

[0040] Chemical etchants can be used to clean accumulated byproducts from an optical surface. However, the etching process may corrode the chamber over time and is expensive. Additional heating of the optical surface may lead to thermally induced focus shift and degradation of the laser beam quality.

[0041] Coils producing magnetic fields have significant design complexity, are expensive, and work well only for deflecting ions, while not being effective for stopping neutrals (and neutral particles), which are produced when ions undergo charge exchange with the buffer gas.

[0042] Debris vanes lead to transmission light loss due to occlusion, require complicated alignment procedures, and any material that ends up condensing on the surface of the debris vanes can be a subject of secondary erosion or sputtering due to high energy ions produced by the source.

[0043] A gas buffer region located between the target and the collector slows down high-energy ions and neutrals but is not as effective at suppressing diffusion of atomic vapor and micro-particles. Buffer gas can provide some protection from small size condensable atomic clusters due to diffusion. However, long interaction length and/or high pressure are required to achieve reasonable debris mitigation efficiency. These requirements, in turn, will lead to increased transmission loss.

[0044] In order to protect the window and/or other optical elements in a plasma-based source chamber from contaminants, certain embodiments of the present invention provide directional gas flow so as to protect against debris. In general, a gas protection system provides a directional and localized protective gas flow at

a relatively high velocity that can push away debris particles or clusters. The protective gas can be comprised of a gas having low absorption characteristics at 13.5nm, such as Argon, to thereby allow efficient light transmission. Certain embodiments of the present invention can also provide mechanisms to prevent
5 undesirable condensation of the gas jets as they exit through multiple nozzles or tubes into the chamber. The terms “tubes” and “nozzles” are used interchangeably herein. Although the following embodiments are described with respect to EUV plasma-based systems, these embodiments are applicable to other types of plasma-based illumination source systems.

10 **[0045]** Suitable excitation sources may include a pulsed laser device, such as a solid state laser, e.g., having a fiber, rod or disk shaped active media, Yb:YAG (Ytterbium doped YAG) with a wavelength of 1030nm or Nd:YAG (neodymium-doped YAG) with a wavelength of 1064nm and others with center wavelength around 1 μm , a MOPA configured excimer laser system, an excimer laser having
15 one or more chambers, e.g., an oscillator chamber and one or more amplifying chambers (with the amplifying chambers in parallel or in series), a master oscillator/power oscillator (MOPO) arrangement, a master oscillator/power ring amplifier (MOPRA) arrangement, a power oscillator/power amplifier (POPA) arrangement, or a solid state laser that seeds one or more excimer or molecular
20 fluorine amplifier or oscillator chambers. In other examples, the system may employ a pulsed gas discharge CO₂ laser device producing radiation at 9.3 μm or 10.6 μm , e.g., with DC or RF excitation, operating at relatively high power, e.g., 10 kW or higher and high pulse repetition rate, e.g., 50 kHz or more. In one particular implementation (for example, in a lithographic system application), the
25 laser may be an axial-flow RF-pumped CO₂ laser having a MOPA configuration with multiple stages of amplification and having a seed pulse that is initiated by a Q-switched Master Oscillator (MO) with low energy and high repetition rate, e.g., 100 kHz or more. From the MO, the laser pulse may then be amplified, shaped, and/or focused before reaching the irradiation region. Continuously pumped CO₂
30 amplifiers may also be used. Depending on the application, an excimer or

molecular fluorine laser operating at high power and high pulse repetition rate may also be utilized. Other designs are possible.

[0046] In some embodiments, the target material 108 is deposited via a target material delivery system 119, which may be configured to deliver droplets of the target material 108 into the chamber 107 to an irradiation region where the droplets will interact with illumination 102 from the excitation source 102 to ultimately produce a plasma 110 and generate a soft x-ray, EUV, or VUV emission that is collected and focused by a collector element 112 to an intermediate focus point 114. Alternatively, the collector optic may include an aperture (not shown) configured to allow illumination from the excitation source 102 to pass through and reach the target material 108 deposited within the irradiation region of the cavity 107. The reflected light may then be directed by any suitable collection side optics (not shown) from the chamber 107.

[0047] The collector optic 112 may include a grazing-incidence mirror or a near-normal incidence collector mirror having a reflective surface in the form of a prolate spheroid (e.g., an ellipse rotated about its major axis), which may include a graded multi-layer coating with alternating layers of molybdenum and silicon, and in some cases one or more high temperature diffusion barrier layers, smoothing layers, capping layers and/or etch stop layers. In some embodiments, the reflective surface of the collector optic has a surface area in the range of approximately 100 and 10,000 cm² and may be disposed approximately 0.1 to 2.5 meters from the target material 102 or irradiation region. Those skilled in the art will appreciate that the foregoing ranges are exemplary and that various optics may be used in place of, or in addition to, the prolate spheroid mirror for collecting and directing light to an intermediate location for subsequent delivery to a device utilizing EUV/VUV illumination, such as an inspection system or a photolithography system.

[0048] The target material 108 may include, but is not necessarily limited to, a material that includes tin, lithium, xenon or combinations thereof. In some embodiments, the target material 108 is delivered in the form of liquid droplets,

solid pellets, and/or solid particles contained within liquid droplets. Alternative targets or target-forming structures may be utilized, such as a drum 109 as shown in the alternative illumination source system 150 of Figure 1B, which may be cooled cryogenically, or utilizing a cold finger. In an embodiment, the cooled drum 109 may be coated with xenon ice. Those skilled in the art will appreciate that various target materials and deposition techniques may be used without departing from the scope of this disclosure.

[0049] The illumination source system 100 may also include a protection system for protecting plasma-facing optical elements in the chamber 107 from plasma-generated debris using high speed directional gas flow. Examples of plasma-facing optical elements may include laser entrance window 106, collector elements, metrology windows, filters, deflectors, mirrors, etc. In one implementation, gas is flowed through small holes in nozzles or tubes positioned around the optical component with such flowing gas serving to push away the debris away from the plasma-facing optical element.

[0050] The gas flow can have longitudinal and transverse components with respect to the one or more debris paths. Longitudinal gas flow has flow direction opposite to the velocity of debris. CFD (computational fluid dynamics) modeling shows that high-speed longitudinal gas flow directed towards the source of the debris is more effective than a stationary buffer gas. Furthermore, simulation results show that gas flow with counter-directional velocity with amplitude comparable to the velocity of micro-particles (~100m/s) efficiently stops contaminants. In the first approximation effectiveness of laser window protection from the atomic vapor deposition can be estimated by calculating the dimensionless Peclet number defined as the ratio of advection of the vapor by the flow to the rate of diffusion, $Pe = vL/D$, where v is the gas flow, L is the characteristic length, and D is the diffusion coefficient of vapor material in the gas. Then, the vapor attenuation factor is equal to $\exp(-Pe)$. Taking Aluminum atomic vapor at room temperature diffusing against the Argon flow also at room temperature, one can estimate the Diffusion coefficient D to be 0.49 m²/s and the

Argon flow required for achieving $Pe=4$ is ~ 0.7 slm. Depending on the desired degree of vapor attenuation, the gas flow for achieving this Peclet number for particular operational conditions can then be determined. For example, a Peclet number, Pe , that is equal to or greater than 4 would provide more than 50 times vapor attenuation. Then, assuming, for example, that argon gas is flown through a gas cone of 80 cm^2 opening area, the flow uniformly expands at an angle $\alpha=45^\circ$ after passing through the gas cone and reaches average pressure of 30 mTorr, which occupies the length $L=10\text{cm}$. Taking Aluminum atomic vapor at room temperature diffusing against the argon flow, one can estimate that Argon flow for achieving $Pe=4$ is ~ 0.7 slm.

[0051] In certain examples, the debris protection system is designed to flow gas out of a plurality of nozzles and away from the optical element at a velocity towards the plasma so as to prevent debris from reaching such optical element resulting in a Peclet number averaged over a protected area of the optical element that is greater than or equal to 2. In other examples, the design achieves a Peclet number that is equal to or greater than 4.

[0052] The gas may be selected to be transmissive with respect to the light that is generated by the plasma. In a EUV application, a gas with high EUV transmission characteristics includes, but is not limited to, Argon, Hydrogen, He, Br_2 , HBr , N_2 or their mixtures.

[0053] In one implementation, debris protection is achieved by positioning small gas nozzles adjacent to the chamber window. These nozzles can be arranged and sized to generate directed gas flows with low divergence, high density, and high speed over a short distance. Additionally, a combination of different geometries (e.g., circular holes, oval, etc.) or gas flow shapes (planar gas curtain, ring-shaped jet, etc.) can be implemented.

[0054] There may be any suitable number of nozzles, and such nozzles may be distributed in any suitable manner. For instance, the nozzles may be evenly distributed or have a higher density in areas of the chamber that are predicted to have more debris presence.

[0055] Gas may be flowed from a gas source (e.g., 118) via a manifold to a plurality of nozzles. That is, the gas source, manifold, and nozzles are fluidly coupled. The manifold may have any suitable shape and size and be comprised of one or more cavities, channels, or any other structure or combination of structures defining one or more independent or shared gas flow pathways.

[0056] In the illustrated example, the illumination source system 100 includes a gas injection system 116 that provides protective gas injection, one end of this gas injection system 116 can be adjacent to the entrance window 106 (as shown). The gas injection system 116 can be configured to also enclose the entrance window.

[0057] Figure 2A is a perspective view of a gas injection system 200 in accordance with a specific implementation of the present invention. Figure 2B is a side view perspective of the gas injection system of Figure 2A. As shown in Figure 2A, a plurality of gas nozzles 208 are positioned in front of entrance window 204 to flow gas away from the entrance window 204. The gas injection system 200 may also include a cone or other gas-directing structure (220 of Figure 2B).

[0058] A replaceable protective glass (or transparent material) plate or pellicle 206 may be mounted between the laser entrance window 204 and plasma source in the laser beam path for intercepting particulates and protecting the surfaces of entrance window against all forms of contaminants. In this and other embodiments, the directional gas flow can be used to protect the pellicle. In one embodiment, the side of the pellicle facing the plasma may be uncoated to avoid any damage or delamination of an anti-reflective (AR) coating by the debris, while the side away from the plasma can be AR coated to improve the transmission. In other embodiments, the pellicle is replaceable with a new one without having to open the vacuum chamber. For example, a replacement pellicle may be rotated into a position to replace the original pellicle.

[0059] The gas injection system 200 can serve to shape the gas flow while allowing the illumination beam to propagate through the chamber 107. The gas

injection system may comprise a modular design and consist of several stackable cones. As shown in Figure 2B, the gas injection system 200 includes a manifold or gas reservoir 210 for receiving gas through inlet 202. The manifold is connected to a plurality of exit nozzles, e.g., 208a, 208b, and 208c. The gas may
5 be delivered to the manifold via one or more inlets although only a single inlet 202 is shown.

[0060] In general, the gas can be fed into the gas injection system 200 through manifold 210 and out through the exit nozzles. The manifold 210 has higher conductance than the total conductance of all the nozzles, which allows pressure
10 inside it to equilibrate before gas exits through the nozzles. Figure 3 illustrates a cross section of gas flow distribution through 48 gas nozzles to form a protected flow in accordance with one embodiment of the present invention. It is noted that only two nozzles are visible in Figure 3. For chamber portion 302, different gray scales are used to illustrate different gas velocities. As shown, the gas flow has a
15 higher velocity immediately exiting the nozzles (e.g., input portions 304a and 304b), while having a lower velocity as the gas flows out of the cone 310 into the chamber (e.g., into area 306). Uniform distribution is due to the manifold before the nozzles, wherein flows are not shown. The gas flow is uniformly distributed among the nozzles, providing uniform protection of the entrance window and/or
20 pellicle if present.

[0061] In certain embodiments, the entrance window and/or pellicle can be made of sapphire material. Because of its high modulus of rupture, sapphire window can be made much thinner than other common optical windows, thus minimizing the aberration of the drive laser beam. Due to its excellent thermal conductivity,
25 beam distortion caused by temperature gradient can also be reduced. Furthermore, sapphire is also resistant to UV radiation darkening, which may be useful for an EUV light source since a large amount of out-of-band (OOB) radiation in the UV/DUV/VUV range is emitted along with the desired 13.5nm wavelength.

[0062] When the gas expands after exiting a nozzle, the temperature of the gas flow decreases rapidly. In some cases, the temperature can become so low that gas begins to liquefy. Nozzle flow can be changed substantially by the formation of liquid as it may alter gas velocity, temperature, and pressure. It would be beneficial to reduce condensation for applications in which the gas flow is being used to protect sensitive optical components from debris since it is the gas phase of protective gas that mitigates the debris, while the condensed phase of protective gas will do little mitigation.

[0063] To solve this condensation problem, gas pressure, number and size of nozzles can be selected to prevent or minimize condensation of the gas at each nozzle exit. Accurate prediction of gas dynamic properties throughout the flow field may be achieved based on CFD (computational fluid dynamics) modeling. With the help of CFD, design parameters can be optimized to minimize or inhibit condensation. The following general nozzle and manifold design guidelines can be used to generally inhibit or substantially minimize condensation.

[0064] When a gas flows from high to low pressure, the gas expands so that its density decreases and its volume increases. As this occurs thermal energy is converted to kinetic energy. That is, the gas gets cold as its speed becomes large. This effect can be significant when the Mach number (ratio of the gas speed to the local sound speed) of the flow becomes greater than 0.3. Large Mach numbers can be associated with injecting any significant amount of gas into a vacuum environment.

[0065] Figure 4A and 4B show the results of a CFD simulation for flowing argon from a high-pressure reservoir, through a tube with a diameter of 0.75 mm and length of 3.2 mm, into a vacuum chamber where the pressure is low. The pressure in the reservoir is 6149 Pa, while the pressure in the vacuum chamber is 5 Pa (1Pa~7.5mTorr). Figure 4A shows the gas flow streamlines and the gas temperature, and Figure 4B shows the Mach number. The flow is choked at the outlet of the tube, where the Mach number is unity, and the pressure is well above the vacuum chamber pressure. Such a gas flow is said to be under-

expanded, meaning it is not sufficiently expanded to match the tube outlet pressure to the vacuum chamber pressure. The gas temperature in the reservoir is near a room temperature value (295 K). After the gas exits the tube, it expands and its Mach number increases to a large value. When this effect occurs, the gas gets cold. At the point of minimum temperature 402 (maximum Mach number 404), the pressure (not shown) of the gas is actually below the pressure that exists in most of the vacuum chamber. That is, the gas flow over-expands. A shock wave surrounds the region of high Mach number, and as the gas flows through that shock wave the Mach number is reduced and the temperature and pressure of the gas increase.

[0066] Figure 5 shows that state of the argon, in pressure-temperature (p-T) space, for a path along the centerline of the geometry shown in Figures 4A and 4B, starting from the reservoir and ending in the vacuum chamber. Also shown is the vapor pressure of argon as a function of temperature, where states to the left of this curve correspond to argon in a condensed state and those to the right of this curve correspond to argon in the gaseous state. The gas starts out at 6149 Pa and 295 K, off the graph. As the gas expands its pressure and temperature decrease, the state eventually crossing over from the gaseous region to the condensed region where it reaches a minimum pressure and temperature of 0.2 Pa and 7.3 K. As the argon continues to flow from there, its pressure and temperature begin to increase, eventually crossing back over into the gaseous region. The actual condensation process is not included in this simulation, but condensation is likely to occur where Figure 5 shows argon states in the condensed region. Once condensation has occurred, the gas is likely to stay condensed for a while even after crossing back over into the gaseous region. For instance, it may take a while for the condensed argon to equilibrate with its environment.

[0067] Several protection system designs may be used to prevent condensation. First, the gas pressure in the reservoir can be reduced. All else being equal, a pressure reduction will decrease the rate of gas flow. In order to preserve the

total rate of gas flow, the reduction in reservoir pressure can be combined with an increase in the number of tubes (nozzles) connecting the reservoir and vacuum chamber. Alternatively or additionally, the reduction in reservoir pressure can be combined with an increase in the diameter of the tube(s). Either way, reducing the reservoir pressure results in a decrease in the maximum Mach number that the gas will reach and an increase in the minimum temperature. The reduction in pressure that is achieved depends on a number of factors, including the tube count, tube diameter, tube length, gas flow, etc. For example, as the tube diameter increases, there will be a larger reduction in reservoir pressure because the size of the large Mach number region and the maximum Mach number both increase with tube diameter.

[0068] As discussed above, there is a shock wave that surrounds the high Mach number region downstream of the tube, and this shock wave results in an increase in temperature when the gas flows through such tube. This effect can be used to prevent condensation if the shock wave can be induced to occur early in the gas flow.

[0069] Any suitable mechanism may be used to induce the shock wave to occur early in the gas flow. In a first implementation, the protection system geometry can include one or more intermediate regions, or expansion stages, between the tube and the vacuum chamber. For instance, the protection system can include an intermediate stage that has a diameter larger than that of the tube, but smaller than the vacuum chamber. Examples are described further below.

[0070] In a second implementation, a baffle plate can be placed downstream of the tube outlet. The diameter and length of the intermediate stage, and the diameter and distance from the tube outlet of the baffle, that may be required to prevent or minimize condensation depend on the reservoir pressure and tube diameter.

[0071] In another embodiment, the tubes or nozzles may be heated. Heat transfer from the tube wall increases the temperature of the gas as it flows through the tube. Although the gas will expand and cool upon exiting the tube,

condensation can be avoided if the gas temperature is sufficiently high at the outlet. Even with a room temperature tube, some heat transfer to the gas will occur as it flows through the tube and expands. But this heat transfer is limited because most of the gas expansion, which results in gas cooling that drives the heat transfer, occurs near the outlet of the tube. So regardless of the length of the tube, the heat transfer to the gas will be near zero over the majority of the leading part of it. However, by heating the tube to a large temperature, heat transfer can then occur over the entire length. The tube temperature and its length can be selected to prevent condensation, depending on the tube diameter and reservoir pressure.

[0072] In the following, results are presented of detailed CFD simulations carried out to determine specific designs for preventing condensation, each based on one of the design considerations described above. For the purposes of these specific examples, the gas is assumed to be Argon; the total flow rate is assumed to be 2 slm (standard liters per minute); and the vacuum chamber is assumed to have a pressure of 5 Pa. In each case, the simulations are compared to an initial design based on 12 tubes, each with a diameter of 0.75 mm and a length of 3.2 mm, such that the flow rate through each tube is 0.167 slm. These conditions correspond to the results presented in Figures 4A, 4B, and 5 as discussed above, and result in a prediction that condensation will occur.

[0073] One method of preventing condensation is to increase the number of tubes. For instance, the number of tubes may be increased from 12 to 60. This increased tube count reduces the reservoir pressure to 1616 Pa. Figures 6A and 6B shows the results of the simulation for this case. By dividing the total flow over 60 tubes, the flow rate through each tube is only 0.0333 slm. The region of large Mach number (604) as shown in Figure 6B and the region of small temperature (602) as shown in Figure 6A are much smaller, as compared with Figures 4B and 4A.

[0074] Figure 7 shows the state of the argon flow in p-T space for 12 tubes (701), 48 tubes (702), and 60 tubes (704). The result for 12 tubes is the same as that

presented in Figure 5. The result for 48 tubes (702) is an improvement over the 12-tube result in that the minimum temperature reached is larger, but it still crosses over into the condensed region. The result for 60 tubes (704) is probably sufficient to prevent condensation, but one can add few more tubes to definitely ensure this.

[0075] Condensation can be prevented by increasing the tube diameter, while maintaining a lower tube count. For example, the tube diameter can be increased from 0.75 mm to 3.5 mm, while maintaining a total of 12 tubes. This specific diameter increase will result in a reduction in the reservoir pressure from 6149 to 272 Pa. Note that this reservoir pressure is much smaller than that obtained by increasing the number of tubes to 60 (1616 Pa), as discussed above. This shows that the reservoir pressure alone does not determine the likelihood for condensation. That is, the tube diameter also plays a role.

[0076] As the tube diameter increases, the size and magnitude of the large Mach number region increases, and consequently the temperature decreases, all else being equal. As the tube diameter is increased, the reservoir pressure decreases. However, the beneficial effects of the latter may be partially offset by the unfavorable effects of the former. As a result, increasing the tube diameter by a factor of at least 4.7 has been predicted to work well. Figure 8 shows simulation results for increasing the tube diameter. As shown, the size of the region of small temperature (802) is relatively small. If not for the large reduction in reservoir pressure, the size of the region of small temperature would be much larger, and the temperature within that region would be much smaller. Figure 9 shows that the argon remains safely in the gaseous region for a tube diameter of 3.5 mm (902).

[0077] As discussed above for the effect of increasing the number of tubes, 48 tubes was not sufficient to prevent the argon from entering the condensed region in p-T space (see Figure 7). However, by adding an intermediate stage to the geometry the expansion process can be altered such that condensation can be prevented. Figure 10A shows the result of a CFD simulation for 48 tubes, and

Figure 10B shows the same case except with a second stage 1002 added to the geometry. In this embodiment, the second stage 1002 is located downstream of the tube, and it has a diameter of 2.6 mm and a length of 3.2 mm. Figure 10B shows that the size of the small temperature region (1006) immediately downstream of the tube is much smaller than the small temperature region (1004) in Figure 10A.

[0078] The intermediate stage can serve to constrict the gas expansion process, resulting in an elevated pressure there that is significantly larger than what occurs without the second stage. This elevated pressure causes the shockwave to occur much sooner in the gas flow than what otherwise occurs. That shockwave reduces the size of the small temperature region and increases the minimum temperature within it. Beyond the second stage the gas expands again and creates a second region of reduced temperature, but it is a minor reduction compared to the first small temperature region. Figure 11 shows the effect of the second stage on the state of the argon flow in p-T space (1102). As can be seen, there is no concern for condensation in the design with the second stage.

[0079] Another way to induce a shockwave in a flow is to add a baffle plate that is perpendicular to the primary gas flow direction. Figure 12 shows the results of a CFD simulation for a debris protection system having a baffle plate (1202) with a diameter of 2.4 mm and located 1 mm downstream of the tube outlet. The gas exits the tube and impinges upon the baffle plate 1202, which forces the flow to spread out radially in order to flow into the vacuum chamber. As in the design discussed above with a second stage, there are two regions that have locally small temperature, one before the baffle plate and another near the perimeter of the baffle plate. In this design, the baffle plate is placed sufficiently close to the outlet of the tube to induce the shockwave soon enough in the flow to limit the decrease in temperature in that first region. Figure 13 shows the effect of the baffle plate on the argon state in p-T space (1302a and 1302b). As can be seen, there is no concern for condensation with the baffle plate.

[0080] The debris protection system may also include a mechanism for preventing condensation by heating the tube such that it has an elevated temperature. In one example, the tube temperature was set to 600 K and the tube length was increased to 12.8 mm. Figure 14 shows the effect of tube temperature on the state of the argon. Two curves are shown, where both correspond to a design having a tube length of 12.8 mm, a tube diameter of 0.75 mm, and a flow rate corresponding to 12 tubes total (0.167 slm). The trajectory curve 1402 corresponds to a 600 K temperature, while curve 1404 corresponds to a room temperature. The result for the 600 K tube is better in terms of a larger minimum temperature.

[0081] A debris protection system may also incorporate a heating system, such as 250 of Figure 2B, that is coupled to the tubes or nozzles. One can potentially use tube heating in combination with other techniques discussed above to avoid condensation.

[0082] The above-described techniques and apparatus for preventing gas condensation can be used in different systems in which gas is injected through a nozzle or a combination of nozzles (or tubes). For example, the condensation prevention mechanisms can be used or integrated with the showerhead collector as further described in U.S. Patent Application 2014/0306115, filed on 7 April 2014 by Alexey Kuritsyn, et al., which application is incorporated herein by reference in its entirety.

[0083] Compared to protection schemes using an electric or magnetic field, certain embodiments of the present invention provide protection from both neutral and charged particles. In addition, high-speed directional gas injection provides more effective debris suppression compared to protection method using stationary purge gas. Additionally, certain embodiments of the present invention improve the efficiency of debris mitigation by utilizing directional gas flow and significantly extend the lifetime of laser entrance window and other optical elements, thus significantly improving optics lifetime.

[0084] Soft x-ray, EUV, VUV, or any other band of plasma-generated illumination may be used for semiconductor process applications, such as inspection, photolithography, or metrology. For example, as shown in Figure 15, an inspection system 1500 may include an illumination source system 1502 incorporating a debris protection illumination source system, such as the illumination source system 100 described above. The inspection system 1500 may further include a stage 1506 configured to support at least one sample 1504, such as a semiconductor wafer or a mask. The illumination source 1500 may be configured to illuminate the sample 1504 via an illumination path, and illumination that is reflected, scattered, or radiated from the sample 1504 may be directed along an imaging path by any suitable collection optics to at least one detector 1510 (e.g. camera or array of photo-sensors). A computing system 1512 that is communicatively coupled to the detector 1510 may be configured to process signals associated with the detected illumination signals to locate and/or measure various attributes of one or more defects of the sample 1504 according to an inspection algorithms embedded in program instructions 1516 executable by a processor of the computing system 1512 from a non-transitory carrier medium 1514.

[0085] For further example, Figure 16 generally illustrates a photolithography system 1600 including an illumination source 1602 incorporating a debris protection illumination source system, such as 100 described above. The photolithography system may include stage 1606 configured to support at least one substrate 1604, such as a semiconductor wafer, for lithography processing. The illumination source 1602 may be configured to perform photolithography upon the substrate 1604 or a layer disposed upon the substrate 1604 with illumination transferred by the illumination source system 100 along the illumination delivery path to an output of the illumination source 1602. For example, the output illumination may be directed from a reticle 1608 to the substrate 1604 to pattern the surface of the substrate 1604 or a layer on the substrate 1604 according an illuminated reticle pattern. The exemplary embodiments illustrated in Figure 15 and 16 generally depict applications of any

of the debris-mitigated illumination source systems described above. However, those skilled in the art will appreciate that debris protection systems as described herein can be applied in a variety of contexts without departing from the scope of this disclosure.

5 **[0086]** Those having skill in the art will further appreciate that there are various vehicles by which processes and/or systems and/or other technologies described herein can be effected (e.g., hardware, software, and/or firmware), and that the preferred vehicle will vary with the context in which the processes and/or systems and/or other technologies are deployed. In some embodiments, various steps,
10 functions, and/or operations are carried out by one or more of the following: electronic circuits, logic gates, multiplexers, programmable, logic devices, ASICs, analog or digital controls/switches, microcontrollers, or computing systems. A computing system may include, but is not limited to, a personal computing system, mainframe computing system, workstation, image computer, parallel
15 processor, or any other device known in the art. In general, the term "computing system" is broadly defined to encompass any device having one or more processors, which execute instructions from a carrier medium. Program instructions implementing methods such as those described herein may be transmitted over or stored on carrier media. A carrier medium may include a
20 transmission medium such as a wire, cable, or wireless transmission link. The carrier medium may also include a storage medium such as a read-only memory, a random access memory, a magnetic or optical disk, or a magnetic tape.

[0087] All of the methods described herein may include storing results of one or more steps of the method embodiments in a storage medium. The results may
25 include any of the results described herein and may be stored in any manner known in the art. The storage medium may include any storage medium described herein or any other suitable storage medium known in the art. After the results have been stored, the results can be accessed in the storage medium and used by any of the method or system embodiments described herein, formatted
30 for display to a user, used by another software module, method, or system, etc.

Furthermore, the results may be stored "permanently," "semi-permanently," temporarily, or for some period of time. For example, the storage medium may be random access memory (RAM), and the results may not necessarily persist indefinitely in the storage medium.

5 **[0088]** Figure 17 is a flow chart illustrating a debris protection procedure 1700 in accordance with one embodiment of the present invention. Initially, a gas that is transmissive (for a particular illumination beam) is output from a plurality nozzles towards a chamber location, at which a plasma will form, at a velocity that is selected to stop debris from reaching the entrance window or other components
10 in the chamber in operation 1702. A drive laser may be directed through an entrance window into the vacuum chamber to form a plasma for generating an illumination beam in operation 1704. The illumination beam is also collected and directed towards a sample, such as a wafer or reticle, in operation 1706.

[0089] Although the foregoing invention has been described in some detail for
15 purposes of clarity of understanding, it will be apparent that certain changes and modifications may be practiced within the scope of the appended claims. It should be noted that there are many alternative ways of implementing the processes, systems, and apparatus of the present invention. Accordingly, the present embodiments are to be considered as illustrative and not restrictive, and
20 the invention is not to be limited to the details given herein.

CLAIMS

What is claimed is:

1. A plasma-based illumination apparatus for generating radiation, comprising:

5 a vacuum chamber configured to hold a target material;
an optical element positioned within the vacuum chamber or within a wall of such vacuum chamber;

an illumination source system for generating at least one excitation source that is focused on the target in the vacuum chamber for generating a plasma in
10 the vacuum chamber so as to produce illumination radiation;

a collector system for collecting and directing the produced illumination radiation towards a sample; and

a debris protection system for flowing gas out of a plurality of nozzles and away from the optical element at a velocity towards the plasma so as to prevent
15 debris from reaching such optical element resulting in a Peclet number averaged over a protected area of the optical element that is greater than or equal to 2.

2. The apparatus of claim 1, wherein the produced radiation has an extreme ultraviolet (EUV) wavelength range that is equal to or less than 13.5 nm and the
20 gas transmits EUV light.

3. The apparatus of claim 2, wherein the optical element is an entrance window of the chamber that is positioned between about 0.1 to 2.5 meters from the target material.

25 4. The apparatus of claim 2, wherein an area occupied by a plurality of openings of the nozzles is smaller than a surface area of the optical element.

5. The apparatus of claim 2, wherein a flow rate of the gas is less than 20
30 standard liters per minute (slm).

6. The apparatus of claim 2, wherein the gas comprises one or more of the following gases: Ar, H₂, He, Br₂, HBr, or N₂.

5 7. The apparatus of claim 2, wherein each nozzle has a circular hole and the plurality of nozzles are arranged to produce a uniform gas stream, a planar gas curtain, or a ring-shaped jet.

8. The apparatus of claim 2, wherein the debris protection system further
10 comprises a manifold fluidly coupled between the nozzles and a gas source or gas inlet, wherein the manifold has a higher gas conductance than all the nozzles combined.

9. The apparatus of claim 8, wherein the debris protection system includes a
15 gas cone for directing the gas towards the plasma or another debris source.

10. The apparatus of claim 8, further comprising a pellicle positioned in front of the optical element.

20 11. The apparatus of claim 8, wherein the optical element is an entrance window in the wall of the vacuum chamber through which the focused excitation source is received.

12. The apparatus of claim 11, further comprising a pellicle positioned
25 between the optical element and a source of debris, wherein the pellicle and/or entrance window are comprised of a sapphire material.

13. The apparatus of claim 8, further comprising an expansion stage fluidly
coupled between each nozzle and the vacuum chamber, wherein the expansion
30 stage for each nozzle has a diameter larger than a diameter of such nozzle and smaller than a diameter of the vacuum chamber.

14. The apparatus of claim 8, further comprising a baffle positioned downstream of each nozzle.

5 15. The apparatus of claim 8, further comprising a heating system for increasing a temperature of each nozzle to prevent condensation of the gas at each nozzle's exit.

16. The apparatus of claim 8, wherein the nozzles are evenly distributed.

10

17. The apparatus of claim 1, wherein the nozzles have a count and/or size and/or temperature that is selected by a computational fluid dynamics simulation to provide a predefined level of optics protection and to avoid gas condensation.

15 18. An inspection system for inspecting a photolithographic reticle or wafer for defects and the sample is a wafer or reticle, the system comprising:

an apparatus as recited in claim 1 for generating the illumination beam;

imaging optics for directing the illumination radiation towards the reticle or wafer;

20 a detector for receiving a detected signal or image from the reticle or sample in response to the illumination radiation being directed to the reticle or wafer; and

a processor and memory that are configured to analyze the detected signal or image to thereby detect defects on the reticle or wafer.

25

19. A photolithography system for transferring a pattern from a reticle onto a wafer, comprising:

an apparatus as recited in claim 1 for generating the illumination beam;

and

30 imaging optics for directing the illumination radiation via a reticle onto a wafer.

20. The system of claim 1, wherein the debris protection system is further configured for flowing gas out of the plurality of nozzles and away from the optical element at a velocity towards the plasma so as to prevent debris from
5 reaching such optical element resulting in a Peclet number averaged over the protected area of the optical element that is greater than or equal to 4.

21. The system of claim 1, wherein the optical element is a collector element, a metrology window, a filter, a deflector, or a mirror.

10

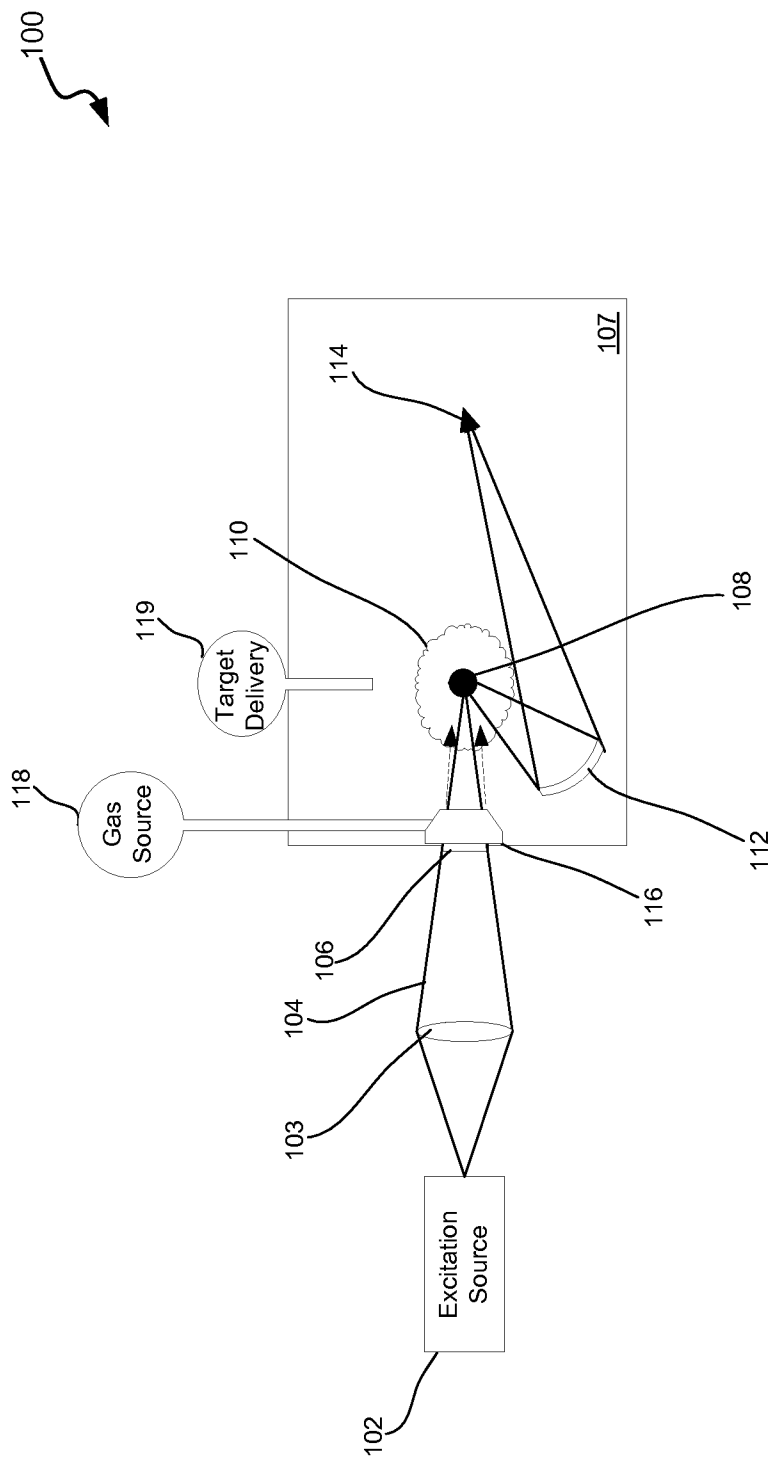


Figure 1A

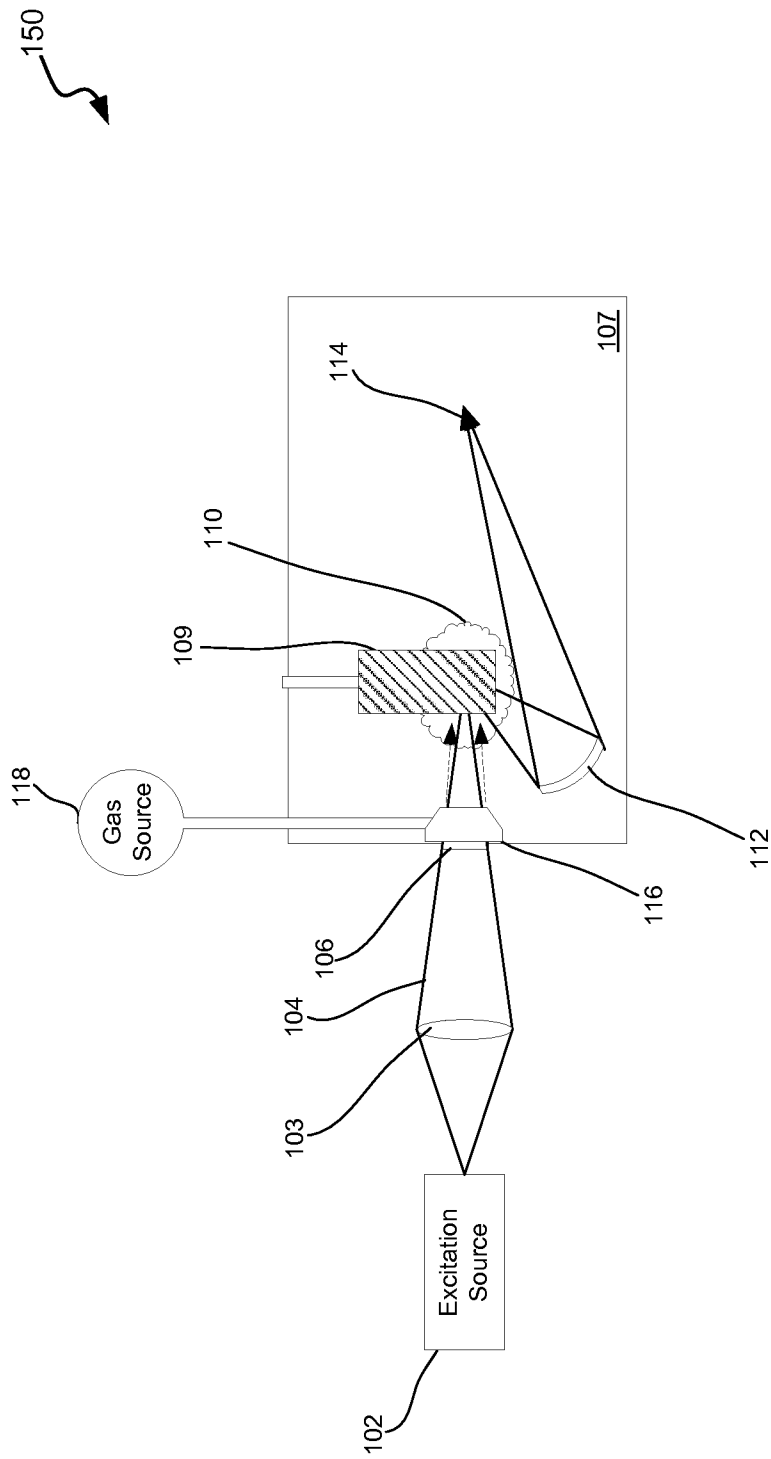


Figure 1B

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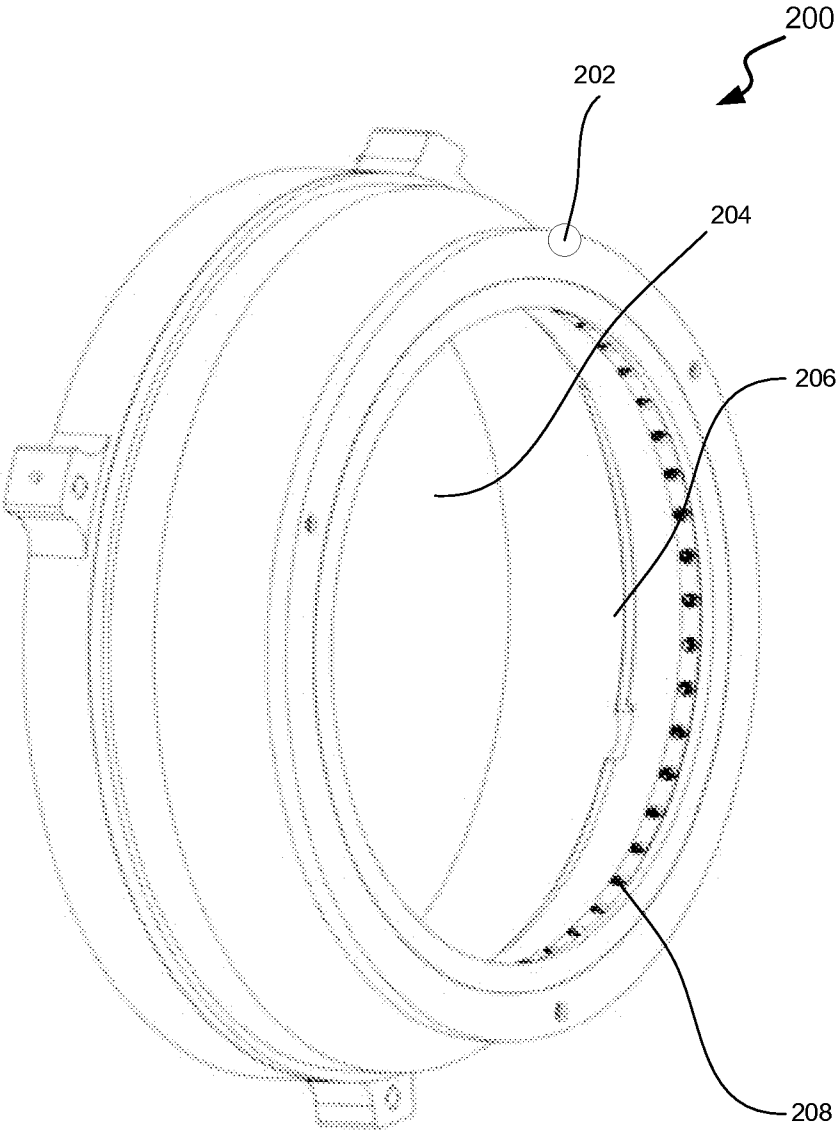


Figure 2A

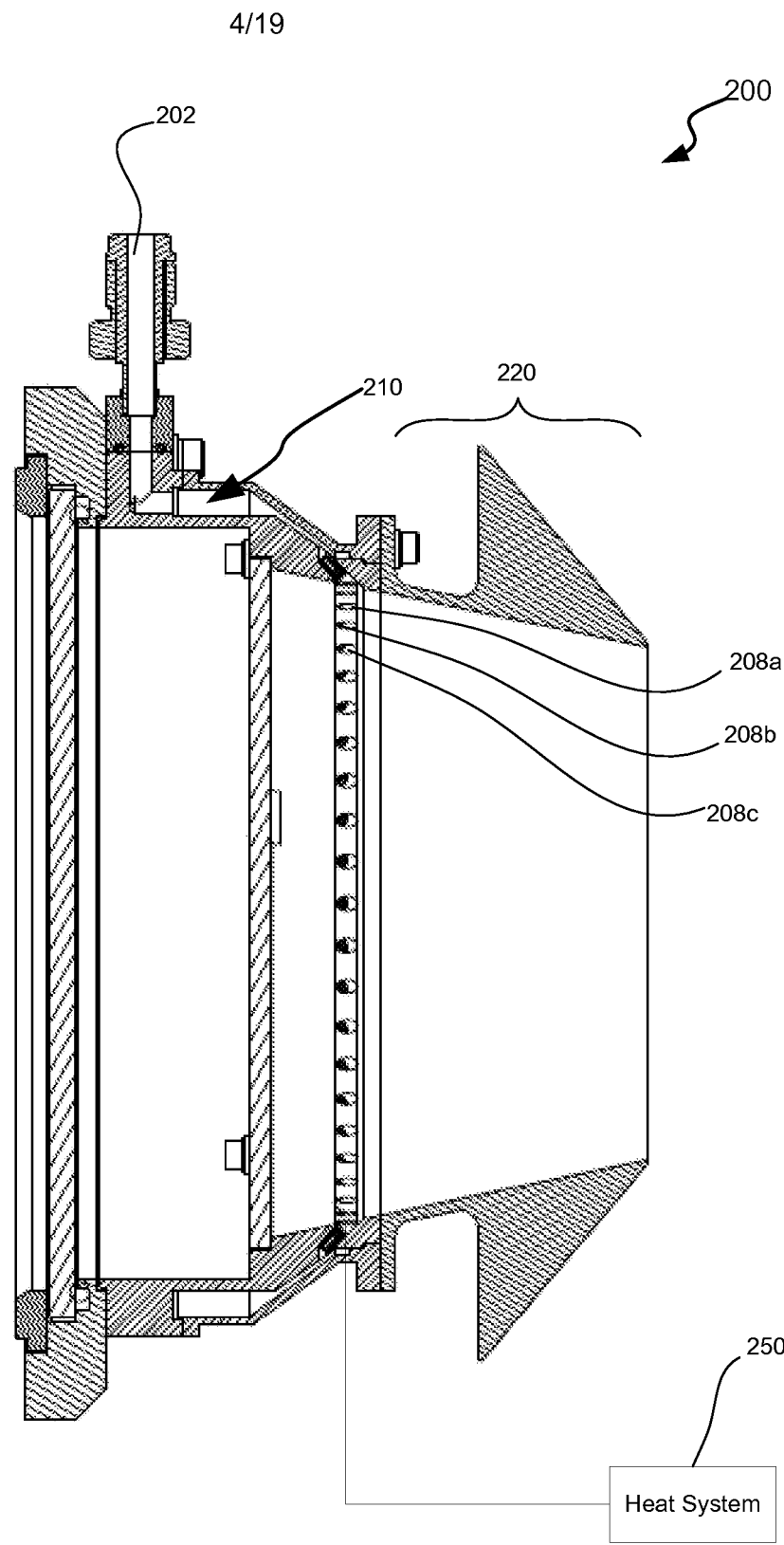


Figure 2B

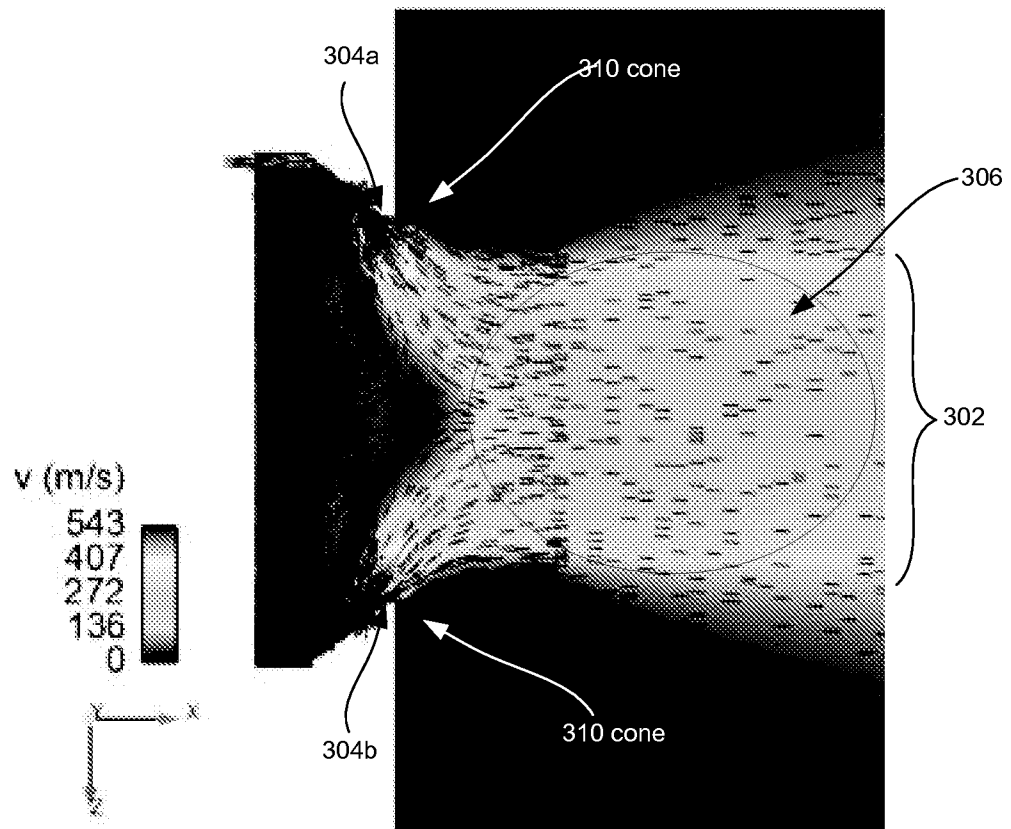
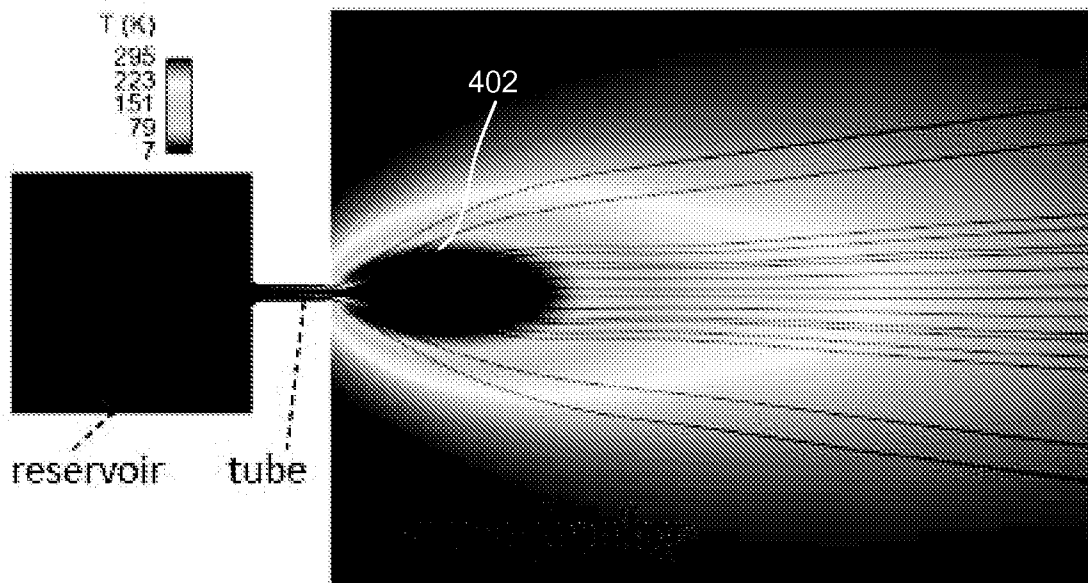
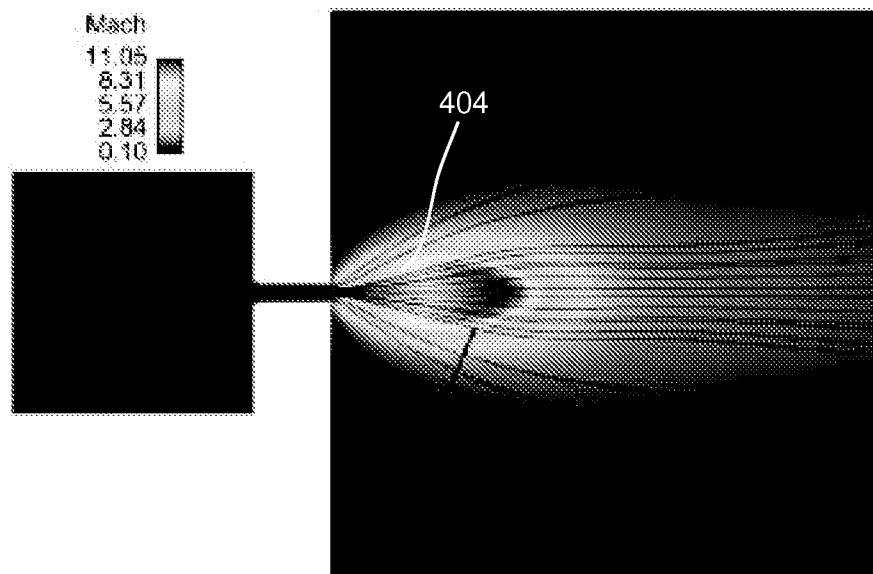


Figure 3

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*Figure 4A**Figure 4B*

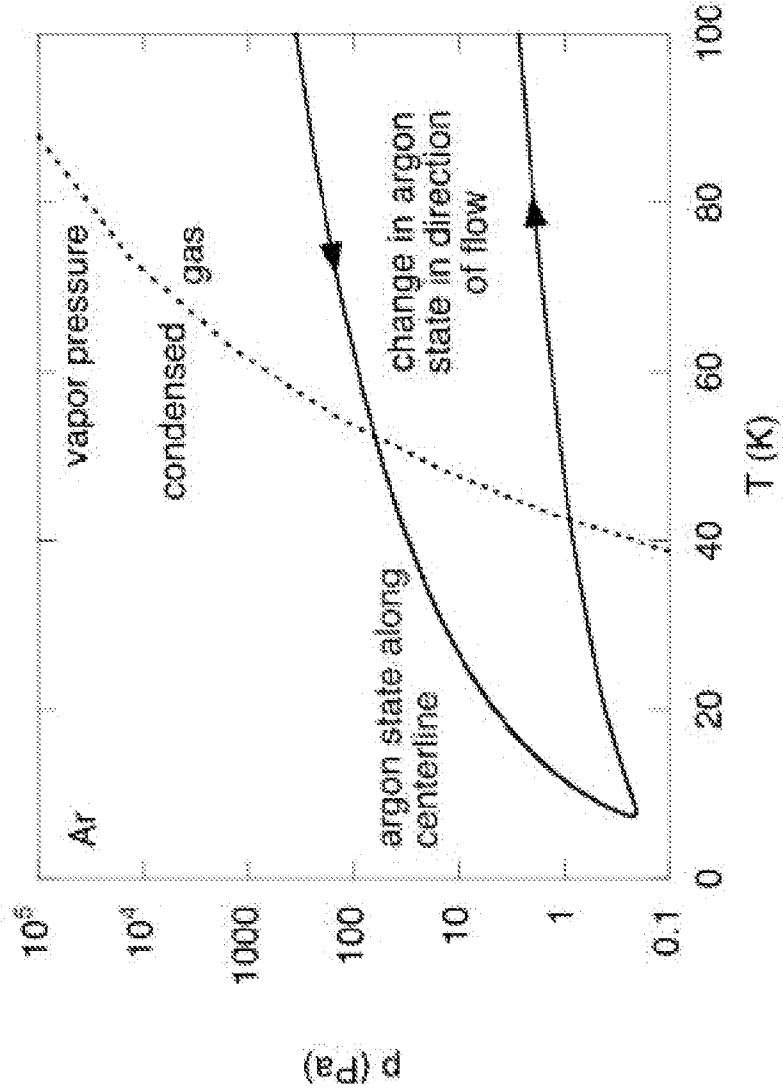


Figure 5

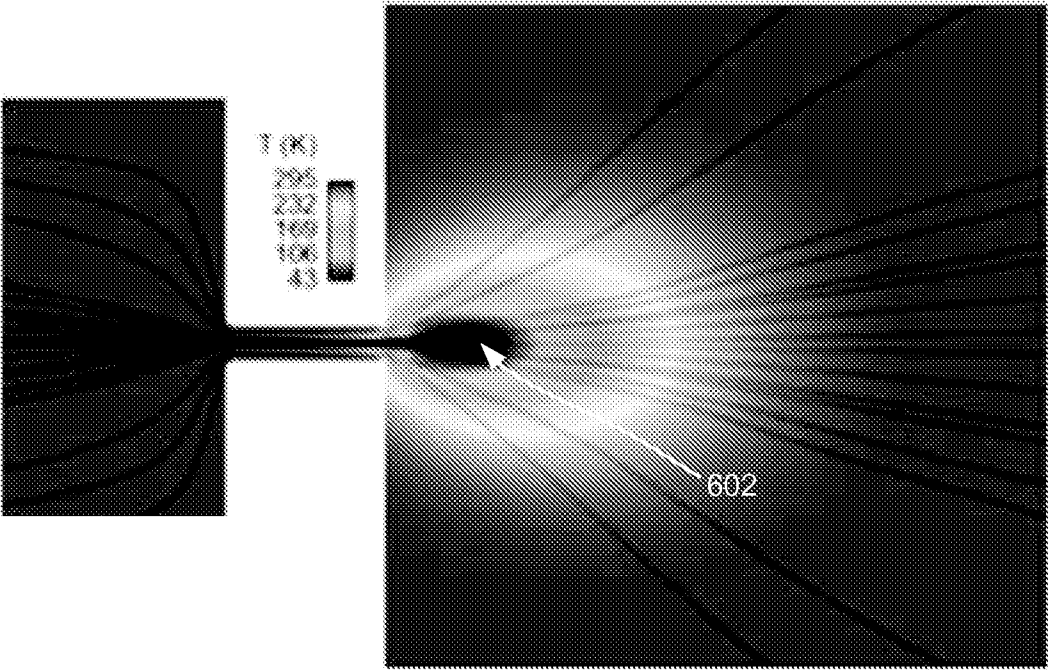


Figure 6A

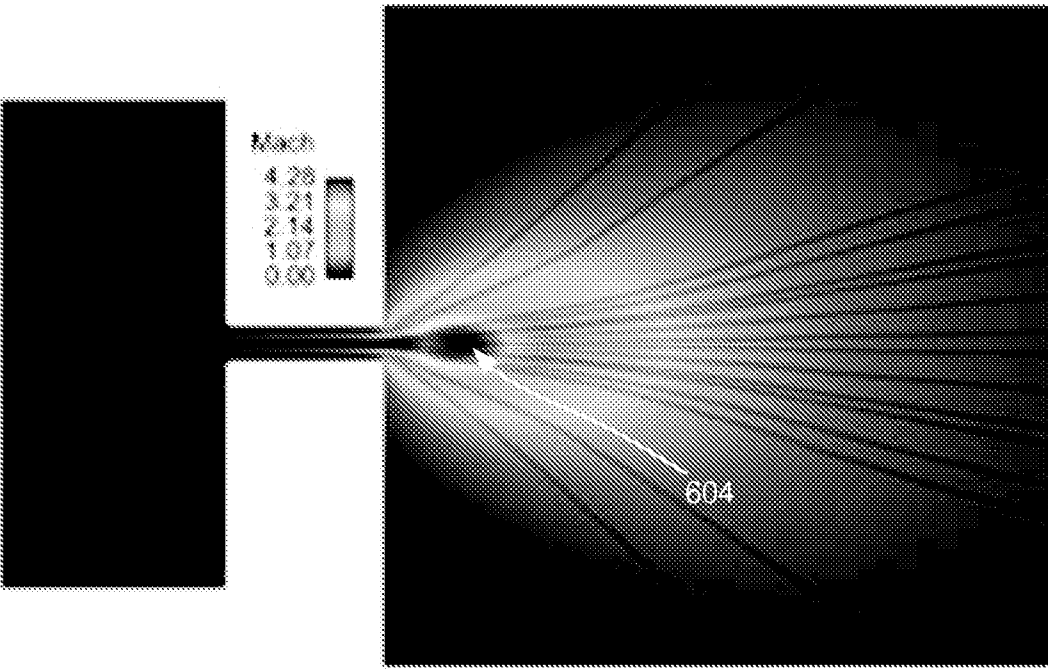


Figure 6B

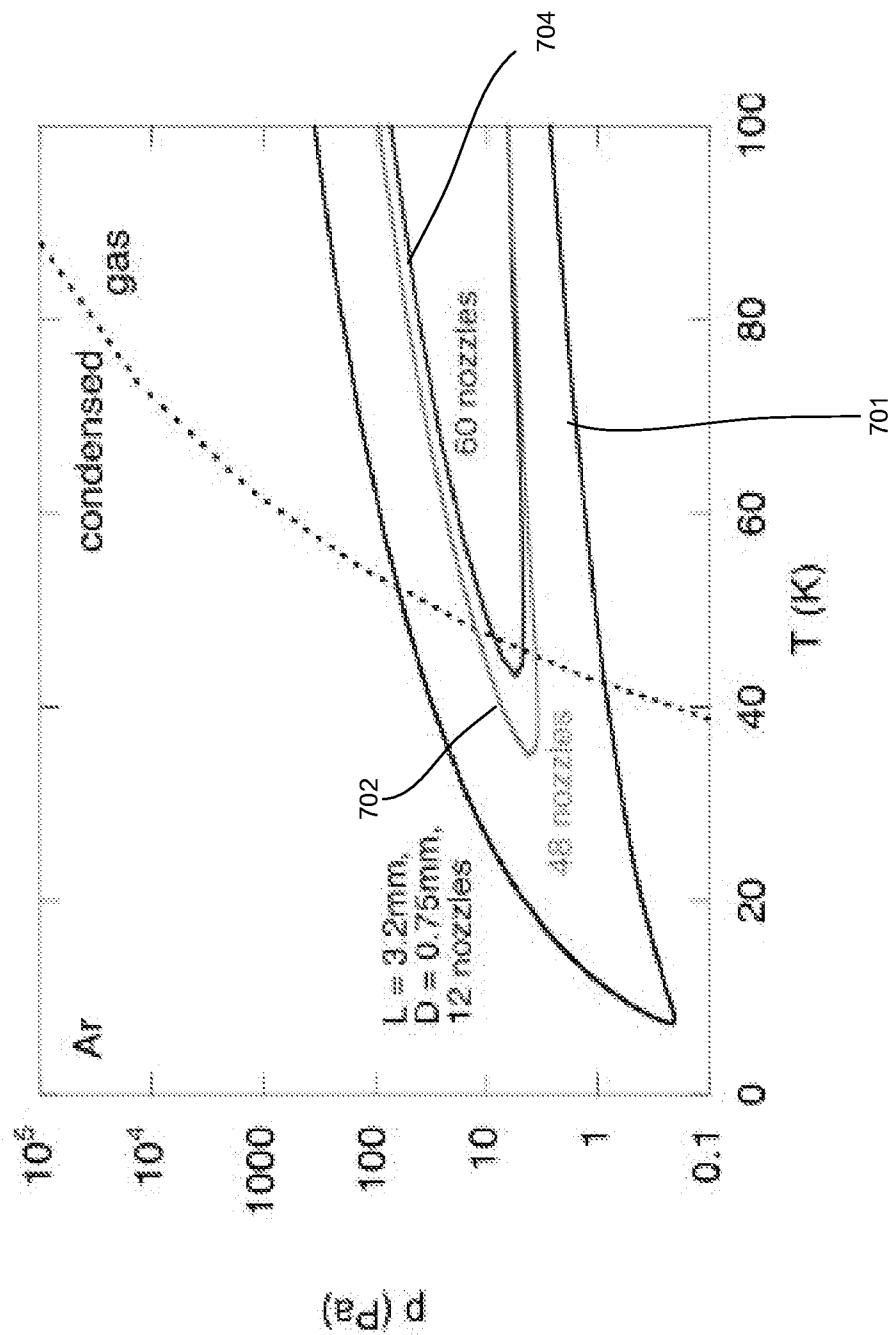


Figure 7

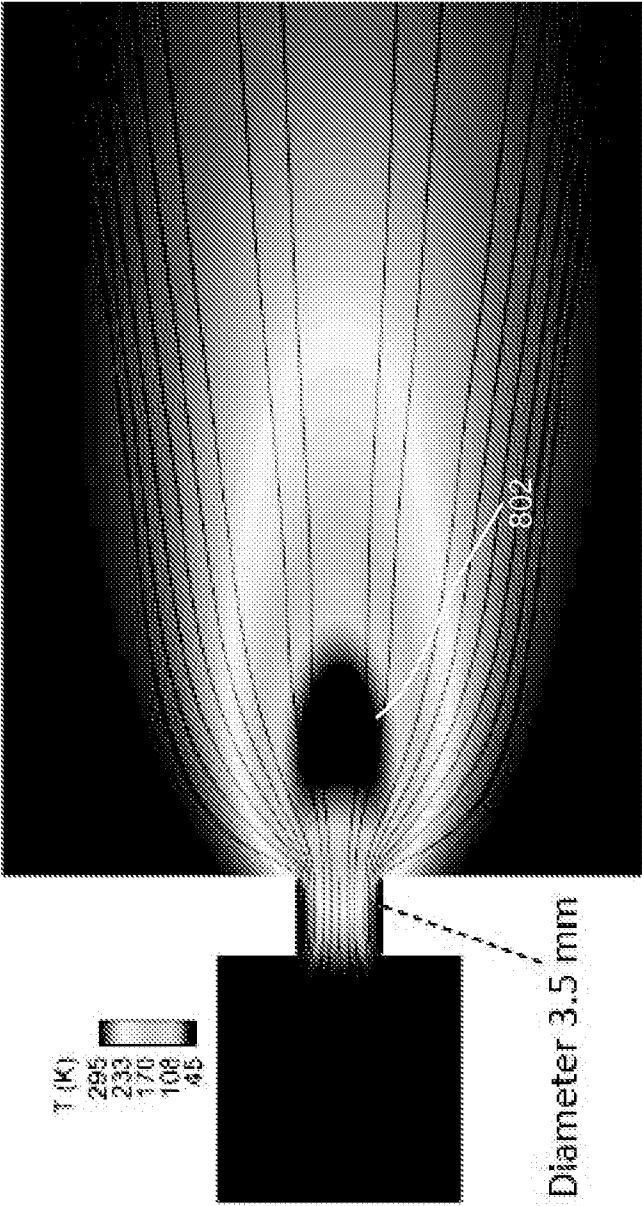


Figure 8

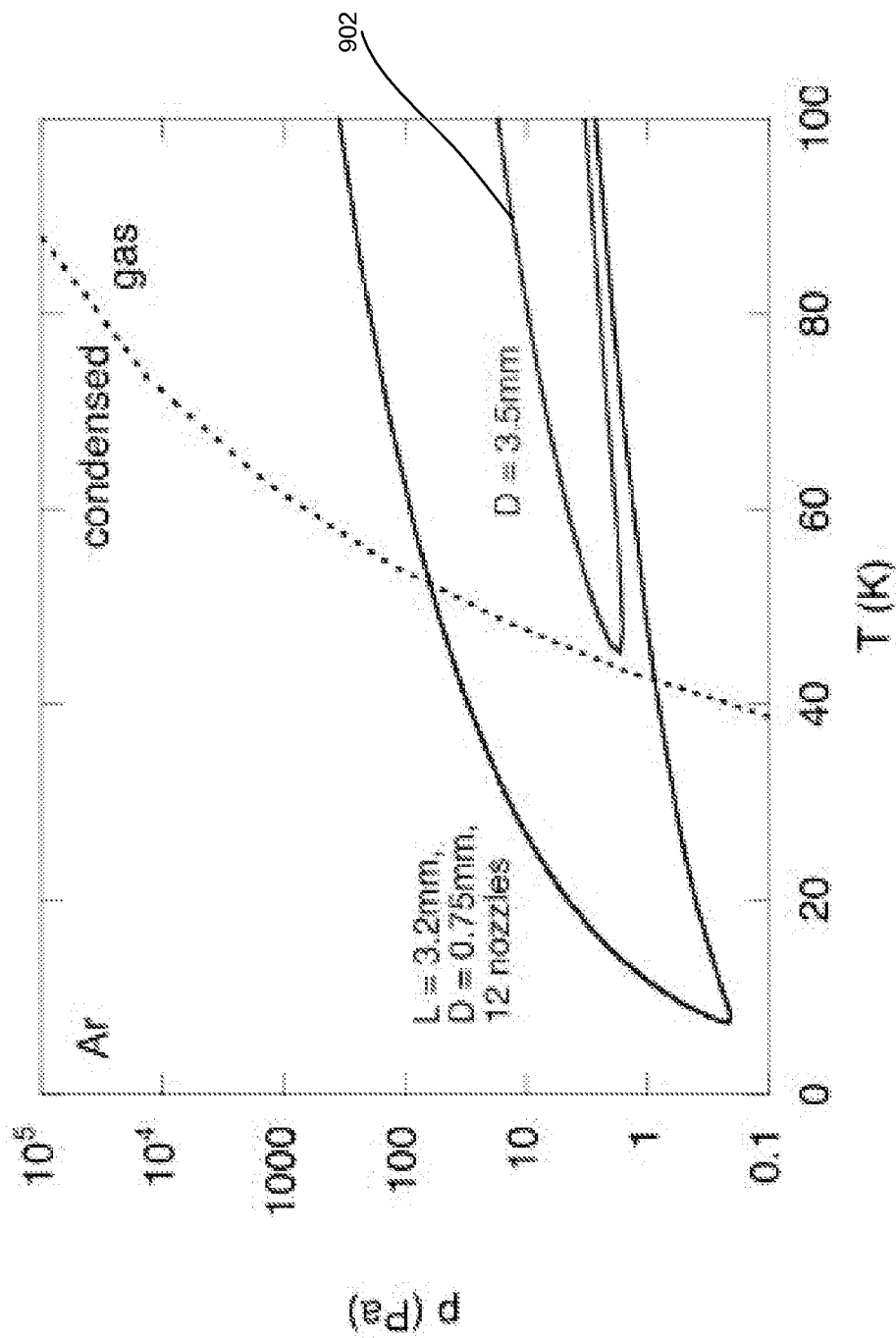
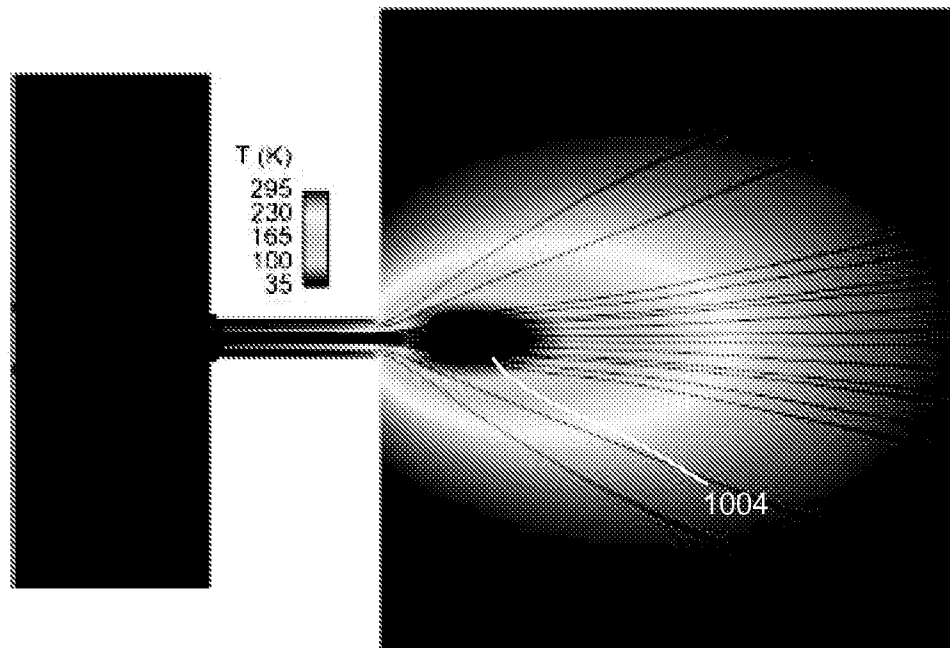
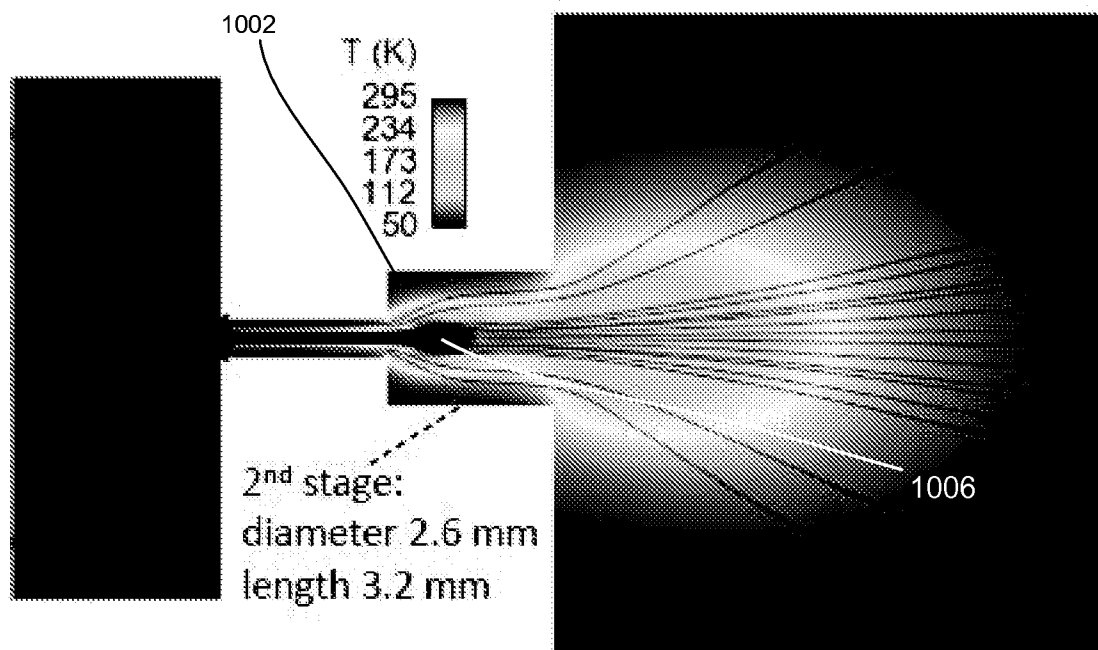


Figure 9

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*Figure 10A**Figure 10B*

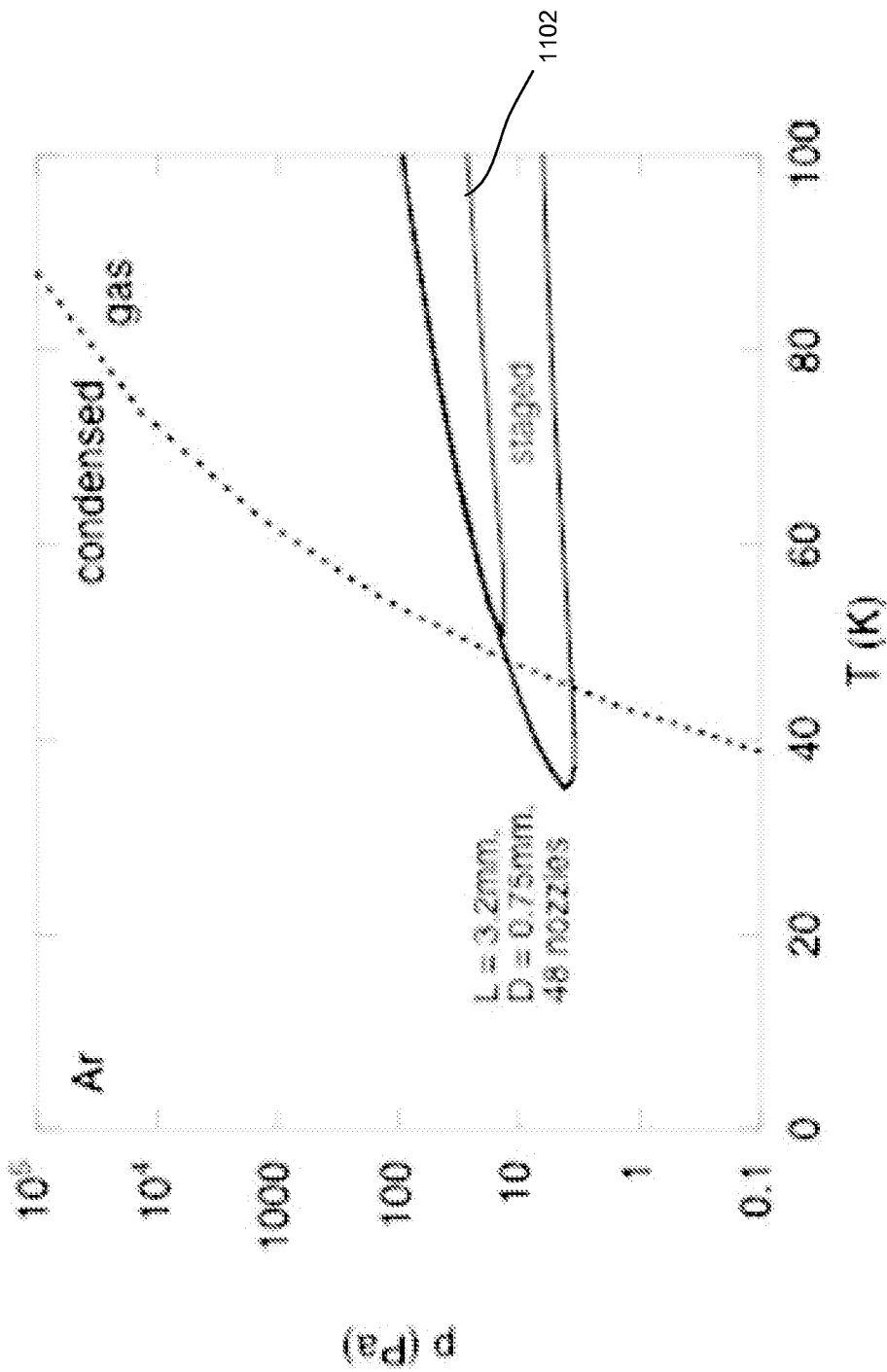


Figure 11

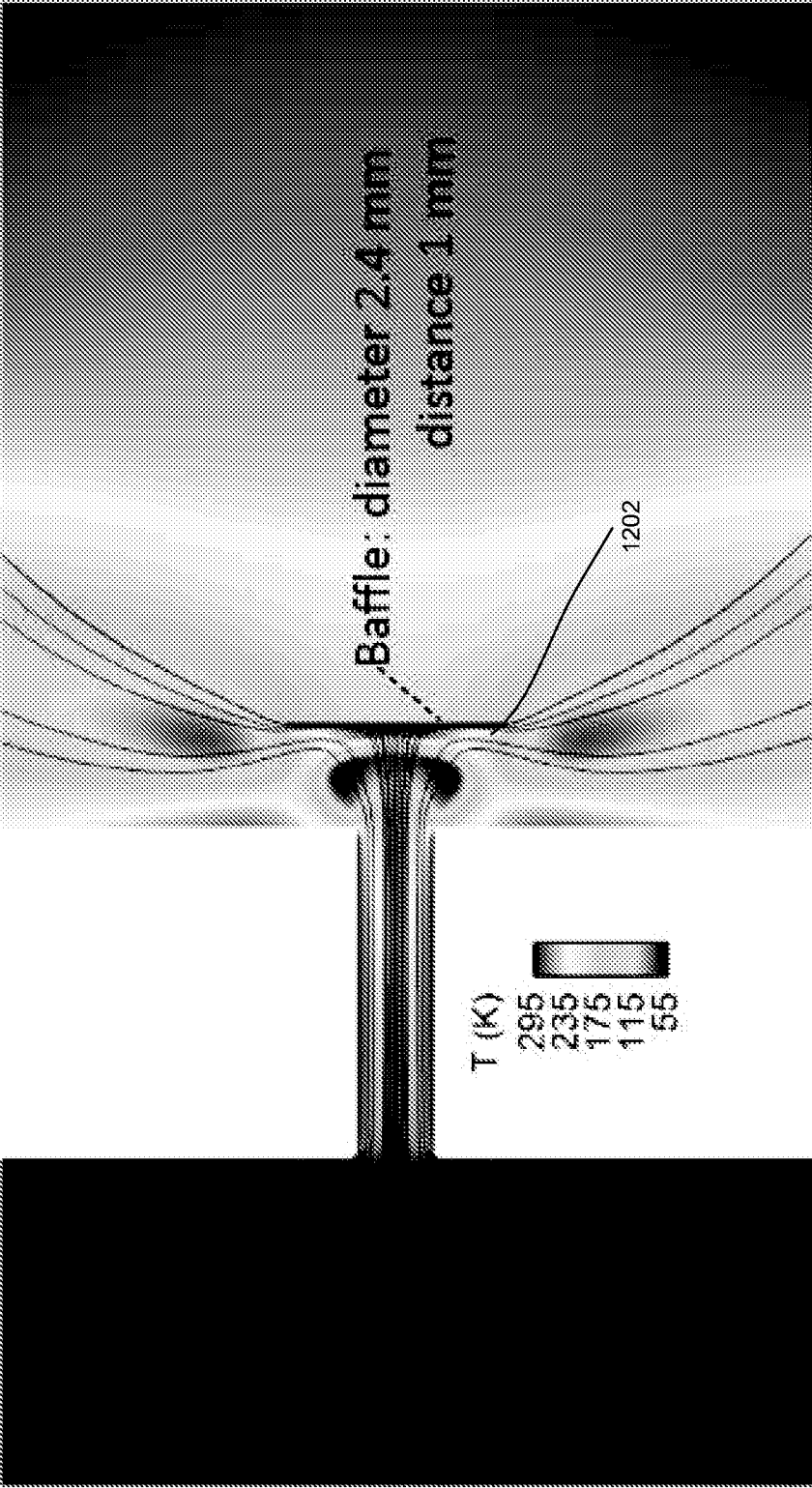


Figure 12

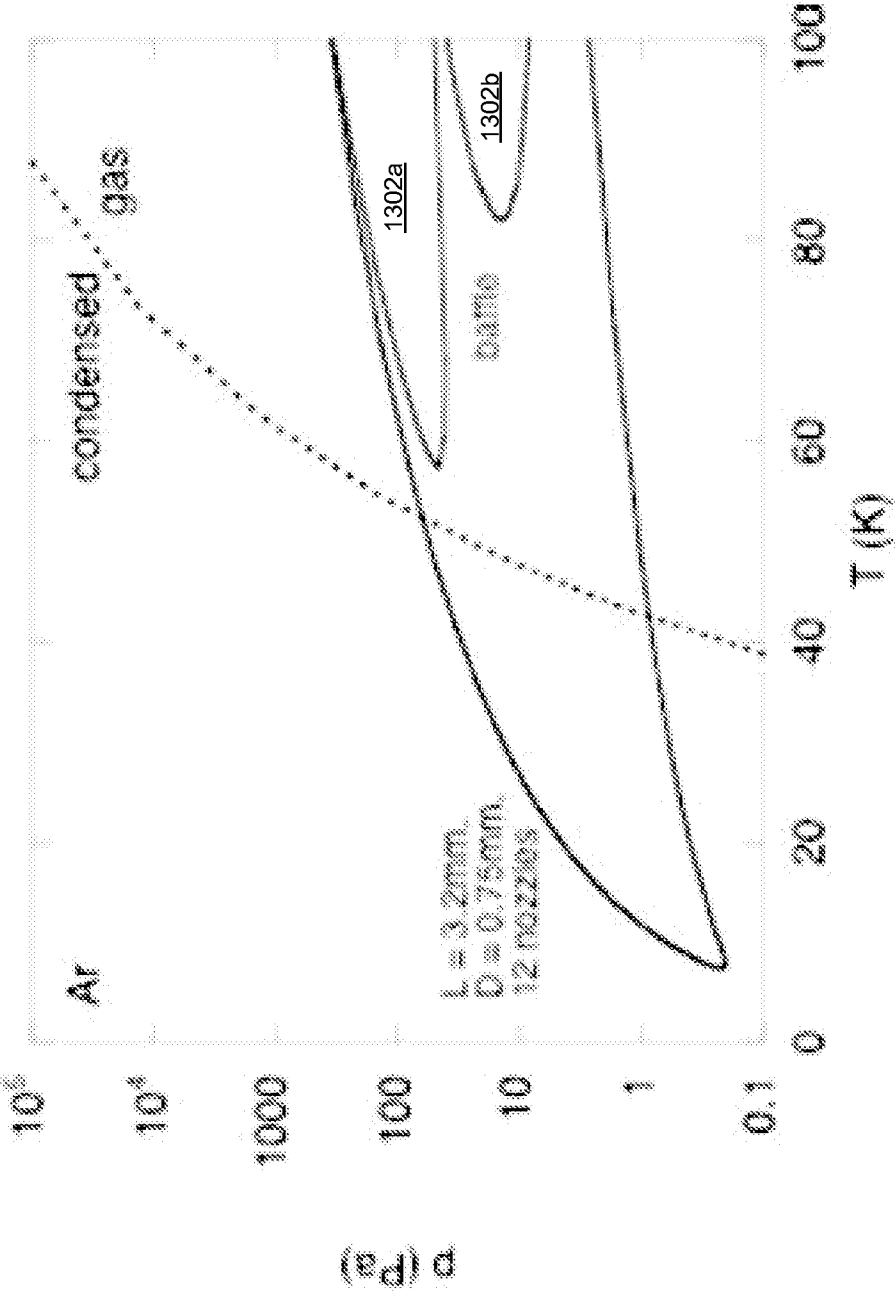


Figure 13

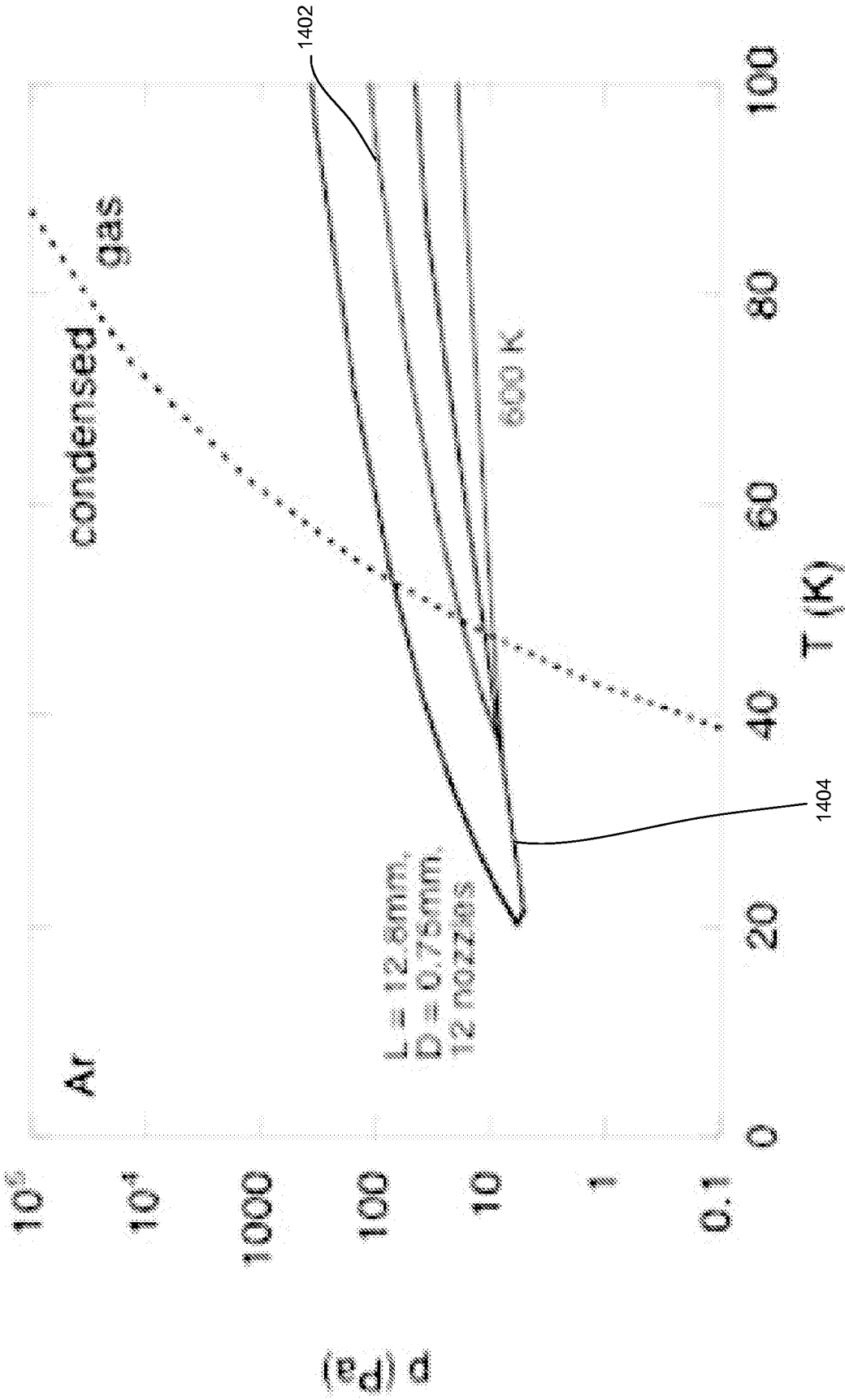


Figure 14

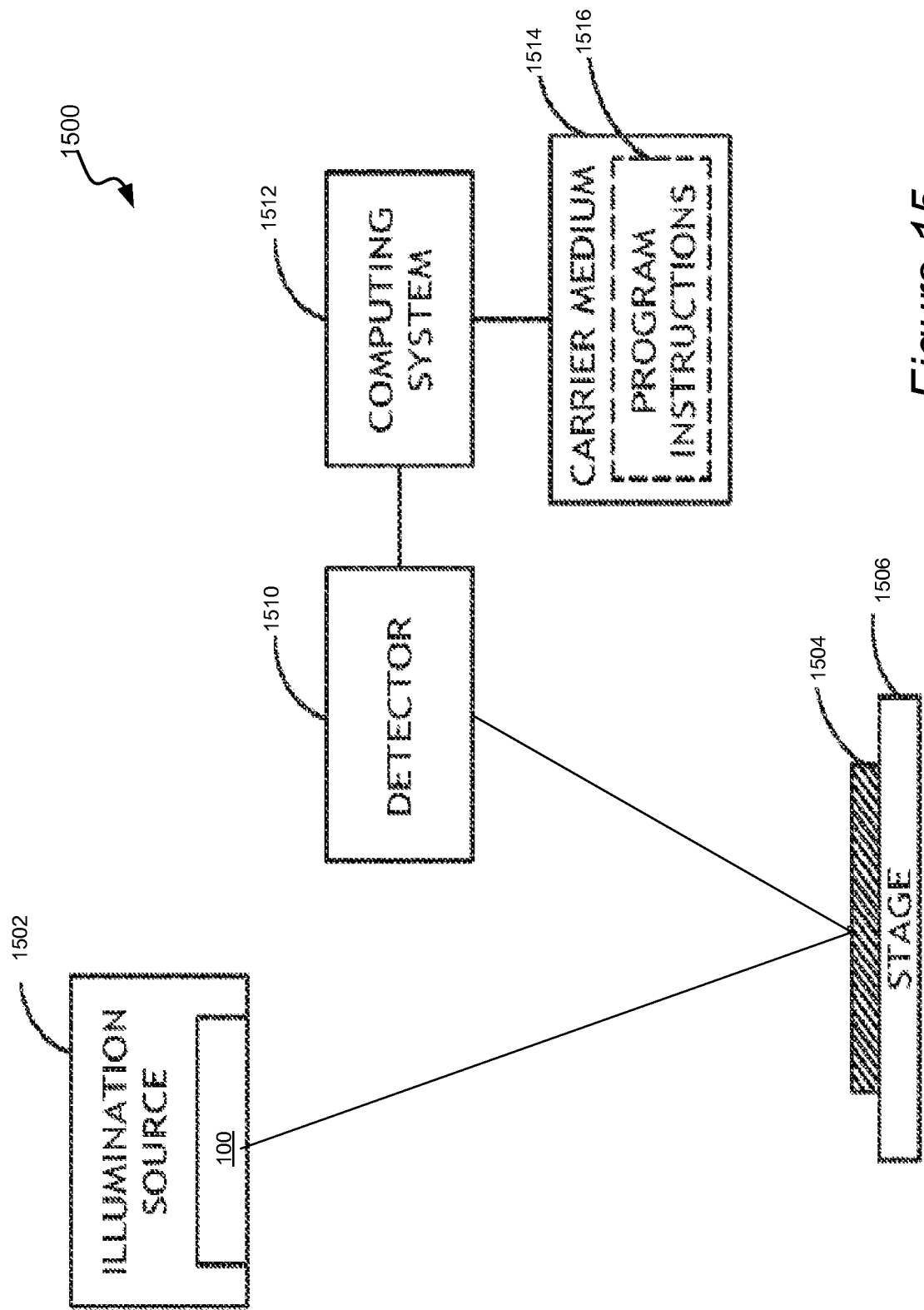


Figure 15

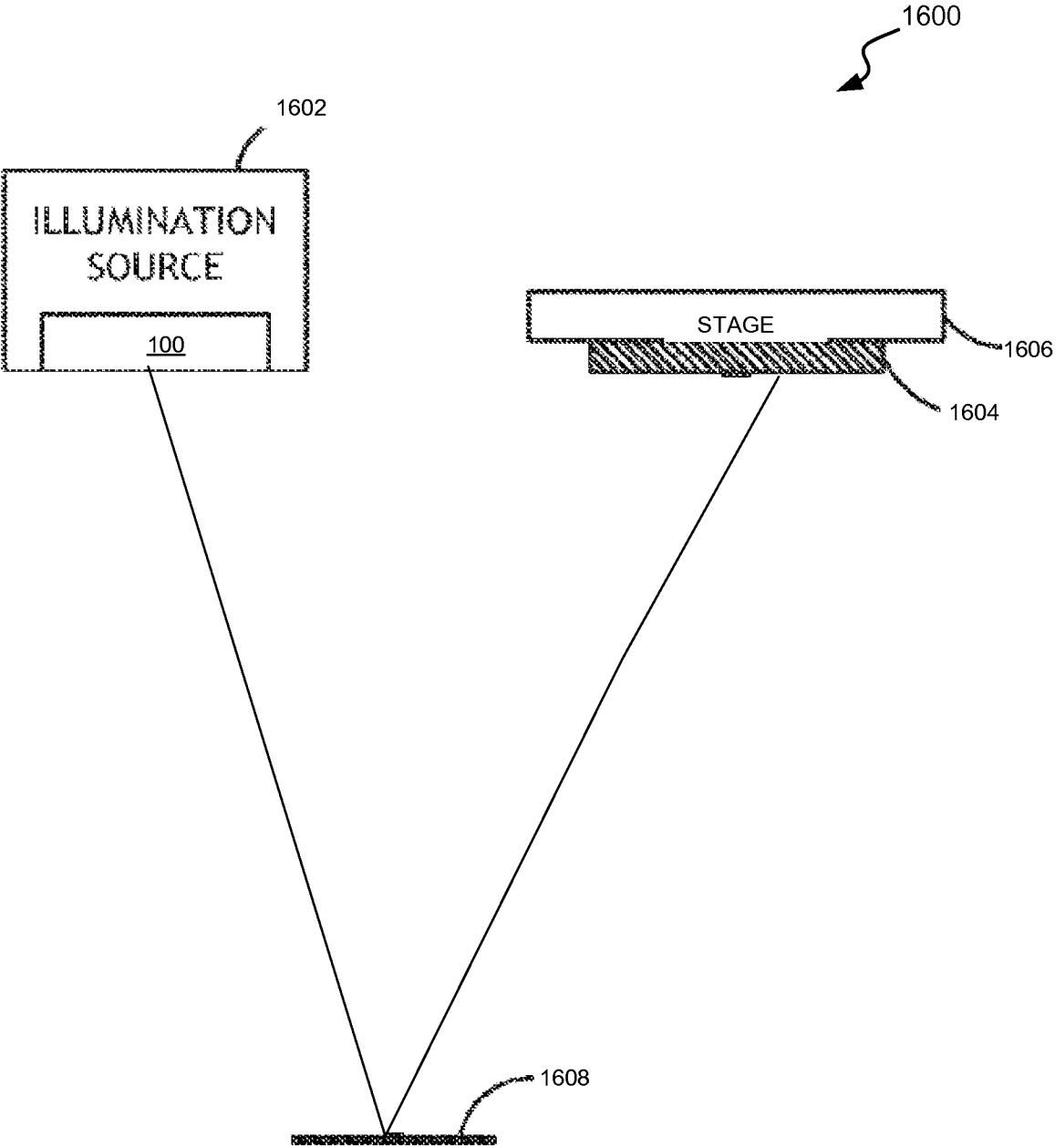
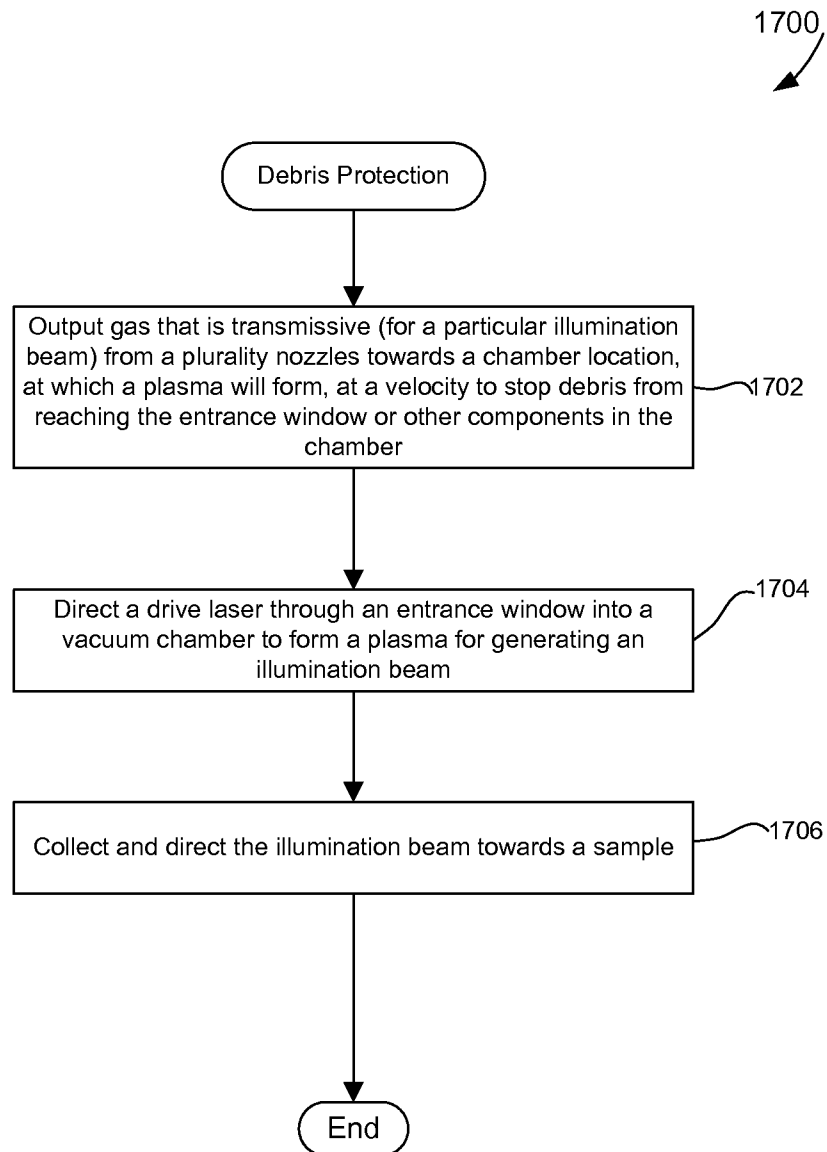


Figure 16

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*Figure 17*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/058650**A. CLASSIFICATION OF SUBJECT MATTER****H05H 1/00(2006.01)i, H01J 17/30(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)

H05H 1/00; G01N 23/20; G03B 27/54; G01J 3/10; H05G 2/00; G02B 27/00; H01J 17/30

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: plasma, photolithography, debris, vacuum chamber, collector system, illumination source

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014-0306115 A1 (KLA-TENCOR CORPORATION) 16 October 2014 See paragraphs [0003], [0026]-[0042], claims 1, 21, 35, and figures 1A-2.	1-14, 16, 18-21
Y		15, 17
Y	US 7247870 B2 (ALEXANDER I. ERSHOV et al.) 24 July 2007 See column 2, lines 37-41, column 3, lines 13-16, and figure 4.	15, 17
A	US 2011-0188014 A1 (VADIM YEVGENYEVICH BANINE et al.) 04 August 2011 See abstract, claims 1-13, and figures 5-7.	1-21
A	US 2007-0080307 A1 (RENE DE BRUIJN et al.) 12 April 2007 See abstract, claims 1-4, and figure 5.	1-21
A	WO 2009-025557 A1 (ASML NETHERLANDS B.V. et al.) 26 February 2009 See claims 12, 30, and figures 2-3.	1-21



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

16 February 2016 (16.02.2016)

Date of mailing of the international search report

16 February 2016 (16.02.2016)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

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Authorized officer

KIM, Sung Gon

Telephone No. +82-42-481-8746



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/058650

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014-0306115 A1	16/10/2014	WO 2014-169071 A1	16/10/2014
US 7247870 B2	24/07/2007	AU 1998-88267 A1	23/04/1999
		AU 1998-91131 A1	03/05/1999
		AU 1998-92975 A1	03/05/1999
		AU 1998-95110 A1	03/05/1999
		AU 1999-16303 A1	28/06/1999
		AU 1999-19139 A1	16/08/1999
		AU 1999-19150 A1	05/07/1999
		AU 1999-22142 A1	16/08/1999
		AU 1999-24592 A1	16/08/1999
		AU 1999-28761 A1	27/09/1999
		AU 1999-32934 A1	20/09/1999
		AU 1999-47151 A1	07/02/2000
		AU 1999-50791 A1	06/12/1999
		AU 1999-52028 A1	06/12/1999
		AU 1999-60300 A1	03/04/2000
		AU 1999-60434 A1	17/04/2000
		AU 2000-18313 A1	19/06/2000
		AU 2000-29590 A1	12/07/2000
		AU 2000-31187 A1	12/07/2000
		AU 2000-59057 A1	13/02/2001
		AU 2000-66084 A1	05/03/2001
		AU 2000-69142 A1	26/03/2001
		AU 2000-71125 A1	10/04/2001
		AU 2000-74749 A1	10/04/2001
		AU 2000-78301 A1	30/04/2001
		AU 2001-13263 A1	05/03/2001
		AU 2001-14412 A1	30/05/2001
		AU 2001-18002 A1	12/06/2001
		AU 2001-20686 A1	09/07/2001
		AU 2001-27683 A1	07/08/2001
		AU 2001-27961 A1	20/08/2001
		AU 2001-30717 A1	30/04/2001
		AU 2001-34355 A1	03/07/2001
		AU 2001-34460 A1	20/08/2001
		AU 2001-36349 A1	27/08/2001
		AU 2001-41421 A1	20/08/2001
		AU 2001-61037 A1	24/12/2001
		AU 2001-62949 A1	24/12/2001
		AU 2001-66831 A1	02/01/2002
		AU 2001-68288 A1	17/12/2001
		AU 2001-69689 A1	14/01/2002
		AU 2001-76818 A1	24/12/2001
		AU 2001-76819 A1	24/12/2001
		AU 2001-76820 A1	24/12/2001
		AU 2001-76821 A1	02/01/2002
		AU 2001-78862 A1	14/01/2002
		AU 2001-90510 A1	08/01/2002

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/058650

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		AU 2001-94509 A1	02/01/2002
		AU 2001-96334 A1	22/04/2002
		AU 2002-14560 A1	15/05/2002
		AU 2002-15318 A1	15/05/2002
		AU 2002-239525 A8	18/06/2002
		AU 2002-306892 A1	08/10/2002
		AU 2002-324905 A8	24/03/2003
		AU 2002-332801 A1	18/03/2003
		AU 2002-336374 A1	18/03/2003
		AU 2002-353869 A1	17/06/2003
		AU 2002-355718 A1	17/02/2003
		AU 2002-39525 A1	18/06/2002
		AU 2003-212805 A1	04/09/2003
		AU 2003-223725 A1	11/11/2003
		AU 2003-228848 A1	11/11/2003
		AU 2003-230870 A1	27/10/2003
		AU 2003-237901 A1	31/12/2003
		AU 2003-249614 A1	12/12/2003
		AU 2003-261337 A1	16/02/2004
		CA 2181598 A1	03/08/1995
		CA 2181598 C	27/03/2001
		CA 2322005 A1	10/09/1999
		CA 2322005 C	18/03/2003
		CA 2359225 A1	03/08/2000
		CA 2359225 C	07/04/2009
		CA 2363949 A1	31/08/2000
		CA 2377832 A1	01/02/2001
		CA 2390123 A1	07/06/2001
		CA 2457869 A1	13/03/2003
		CA 2458111 A1	13/03/2003
		CA 2458619 A1	13/03/2003
		CN 100350686 C	21/11/2007
		CN 100397732 C	25/06/2008
		CN 100458357 C	04/02/2009
		CN 100508308 C	01/07/2009
		CN 100538259 C	09/09/2009
		CN 100571959 C	23/12/2009
		CN 101160698 A	09/04/2008
		CN 101194341 A	04/06/2008
		CN 101194341 B	08/12/2010
		CN 102256429 A	23/11/2011
		CN 102256429 B	14/01/2015
		CN 1204591 C	01/06/2005
		CN 1232010 C	14/12/2005
		CN 1295729 A	16/05/2001
		CN 1365529 A	21/08/2002
		CN 1390360 A	08/01/2003
		CN 1402897 A	12/03/2003
		CN 1522484 A	18/08/2004
		CN 1522484 C	03/09/2008

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/058650

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		CN 1596492 A	16/03/2005
		CN 1674205 A	28/09/2005
		CN 1674205 C	24/12/2008
		CN 1742413 A	01/03/2006
		CN 1771072 A	10/05/2006
		CN 1771072 B	01/06/2011
		CN 1860343 A	08/11/2006
		CN 1860344 A	08/11/2006
		CN 1886228 A	27/12/2006
		CN 1886872 A	27/12/2006
		EP 0741914 A1	29/12/2004
		EP 0741914 B1	27/07/2005
		EP 0981936 A1	01/03/2000
		EP 0990286 A1	05/04/2000
		EP 0992092 A1	12/04/2000
		EP 0992092 B1	23/04/2003
		EP 0992093 A1	12/04/2000
		EP 0992093 B1	07/05/2003
		EP 0993692 A1	19/04/2000
		EP 0993692 B1	26/12/2007
		EP 0995243 A1	26/04/2000
		EP 0998774 A1	10/05/2000
		EP 1002242 A2	24/05/2000
		EP 1002242 B1	05/07/2006
		EP 1010040 A1	21/06/2000
		EP 1010040 B1	24/06/2009
		EP 1012929 A2	28/06/2000
		EP 1019992 A1	19/07/2000
		EP 1019992 B1	14/06/2006
		EP 1019994 A1	19/07/2000
		EP 1019994 B1	11/08/2004
		EP 1021856 A1	26/07/2000
		EP 1027172 A1	16/08/2000
		EP 1027172 B1	26/12/2007
		EP 1028327 A2	16/08/2000
		EP 1028327 A3	19/11/2003
		EP 1028327 B1	25/01/2006
		EP 1028502 A2	16/08/2000
		EP 1028502 A3	16/08/2000
		EP 1028502 B1	24/10/2007
		EP 1037510 A2	20/09/2000
		EP 1037510 A3	02/01/2004
		EP 1038340 A1	27/09/2000
		EP 1040539 A1	04/10/2000
		EP 1040539 B1	10/11/2004
		EP 1047288 A2	25/10/2000
		EP 1047288 A3	02/01/2004
		EP 1047288 B1	10/06/2009
		EP 1054490 A2	22/11/2000
		EP 1054490 A3	24/01/2001

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/058650

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		EP 1054490 B1	28/07/2004
		EP 1060543 A1	20/12/2000
		EP 1060543 B1	16/07/2008
		EP 1075060 A2	07/02/2001
		EP 1075060 A3	05/11/2003
		EP 1075060 B1	26/03/2008
		EP 1075061 A2	07/02/2001
		EP 1075061 A3	05/11/2003
		EP 1075061 B1	23/04/2008
		EP 1080522 A1	07/03/2001
		EP 1100167 A2	16/05/2001
		EP 1100167 A3	27/03/2002
		EP 1100167 B1	28/07/2004
		EP 1101258 A1	23/05/2001
		EP 1101258 B1	11/05/2005
		EP 1109314 A1	20/06/2001
		EP 1118144 A1	25/07/2001
		EP 1119784 A1	01/08/2001
		EP 1147581 A1	24/10/2001
		EP 1147582 A1	24/10/2001
		EP 1151211 A1	07/11/2001
		EP 1151211 B1	29/03/2006
		EP 1155481 A1	21/11/2001
		EP 1155481 B1	13/03/2013
		EP 1159768 A1	05/12/2001
		EP 1203427 A1	08/05/2002
		EP 1203427 B1	06/10/2004
		EP 1206819 A1	22/05/2002
		EP 1218980 A1	03/07/2002
		EP 1218984 A1	03/07/2002
		EP 1218985 A1	03/07/2002
		EP 1218986 A1	03/07/2002
		EP 1218986 B1	08/10/2008
		EP 1224717 A1	24/07/2002
		EP 1224717 B1	04/05/2005
		EP 1226634 A1	31/07/2002
		EP 1232517 A1	21/08/2002
		EP 1234358 A1	28/08/2002
		EP 1234358 B1	06/01/2010
		EP 1240694 A1	18/09/2002
		EP 1240694 B1	22/11/2006
		EP 1252691 A1	30/10/2002
		EP 1252691 B1	17/11/2010
		EP 1256149 A1	13/11/2002
		EP 1256149 B1	25/07/2007
		EP 1258059 A1	20/11/2002
		EP 1258059 B1	23/04/2008
		EP 1258060 A1	20/11/2002
		EP 1258060 B1	06/08/2008
		EP 1287592 A1	05/03/2003

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/058650

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		EP 1297594 A1	02/04/2003
		EP 1297594 B1	15/08/2012
		EP 1303892 A1	23/04/2003
		EP 1303894 A1	23/04/2003
		EP 1305813 A1	02/05/2003
		EP 1310022 A2	14/05/2003
		EP 1310022 B1	24/08/2011
		EP 1323216 A1	02/07/2003
		EP 1330859 A1	30/07/2003
		EP 1330859 B1	20/12/2006
		EP 1330860 A1	30/07/2003
		EP 1330860 B1	17/06/2009
		EP 1330861 A1	30/07/2003
		EP 1339519 A2	03/09/2003
		EP 1340106 A2	03/09/2003
		EP 1340106 B1	09/01/2008
		EP 1366390 A2	03/12/2003
		EP 1373877 A1	02/01/2004
		EP 1373877 B1	24/01/2007
		EP 1378035 A1	07/01/2004
		EP 1378036 A1	07/01/2004
		EP 1378036 B1	01/04/2009
		EP 1378037 A1	07/01/2004
		EP 1378038 A1	07/01/2004
		EP 1380000 A2	14/01/2004
		EP 1382095 A1	21/01/2004
		EP 1386376 A1	04/02/2004
		EP 1386376 B1	01/09/2010
		EP 1386377 A1	04/02/2004
		EP 1386378 A1	04/02/2004
		EP 1391017 A1	25/02/2004
		EP 1402605 A1	31/03/2004
		EP 1407521 A1	14/04/2004
		EP 1407521 B1	16/05/2007
		EP 1412182 A2	28/04/2004
		EP 1421653 A1	26/05/2004
		EP 1430573 A1	23/06/2004
		EP 1436866 A2	14/07/2004
		EP 1438772 A2	21/07/2004
		EP 1438774 A2	21/07/2004
		EP 1438774 B1	24/02/2010
		EP 1449284 A1	25/08/2004
		EP 1449284 B1	16/09/2009
		EP 1458066 A2	15/09/2004
		EP 1458066 A3	19/04/2006
		EP 1458066 B1	21/01/2009
		EP 1474844 A1	10/11/2004
		EP 1482369 A1	01/12/2004
		EP 1493039 A2	05/01/2005
		EP 1502288 A2	02/02/2005

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/058650

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		EP 1502334 A1	02/02/2005
		EP 1502334 B1	23/12/2009
		EP 1502335 A2	02/02/2005
		EP 1502335 B1	06/02/2008
		EP 1521942 A2	13/04/2005
		EP 1521942 B1	06/03/2013
		EP 1540783 A2	15/06/2005
		EP 1540783 A4	19/04/2006
		EP 1602116 A2	07/12/2005
		EP 1615695 A2	18/01/2006
		EP 1649558 A2	26/04/2006
		EP 1649565 A2	26/04/2006
		EP 1649568 A2	26/04/2006
		EP 1661216 A2	31/05/2006
		EP 1668312 A1	14/06/2006
		EP 1668313 A1	14/06/2006
		EP 1687877 A2	09/08/2006
		EP 1689552 A2	16/08/2006
		EP 1692750 A2	23/08/2006
		EP 1692750 B1	27/01/2010
		EP 1723472 A2	22/11/2006
		EP 1726028 A2	29/11/2006
		EP 1726028 B1	21/05/2014
		EP 1730763 A2	13/12/2006
		EP 1730763 B1	10/10/2012
		EP 1730764 A2	13/12/2006
		EP 1743405 A2	17/01/2007
		EP 1766737 A1	28/03/2007
		EP 1766737 B1	01/12/2010
		EP 1779410 A2	02/05/2007
		EP 1779410 B1	30/04/2014
		EP 1807866 A2	18/07/2007
		EP 1807866 B1	06/03/2013
		EP 1821377 A2	22/08/2007
		EP 1821377 A3	24/10/2007
		EP 1851520 A2	07/11/2007
		EP 1851520 B1	08/08/2012
		EP 1853882 A2	14/11/2007
		EP 1853882 A4	25/08/2010
		EP 1853882 B1	19/10/2011
		EP 1861903 A2	05/12/2007
		EP 1887912 A2	20/02/2008
		EP 1889000 A2	20/02/2008
		EP 1899115 A2	19/03/2008
		EP 1899697 A2	19/03/2008
		EP 1899697 B1	30/05/2012
		EP 1915596 A2	30/04/2008
		EP 1915596 B1	29/10/2014
		EP 1944841 A2	16/07/2008
		EP 1944841 A3	05/11/2008

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/058650

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		EP 2036170 A2	18/03/2009
		EP 2036170 B1	21/08/2013
		EP 2115406 A2	11/11/2009
		EP 2137796 A1	30/12/2009
		EP 2259390 A1	08/12/2010
		EP 2375513 A2	12/10/2011
		JP 02942544 B2	30/08/1999
		JP 02963692 B2	18/10/1999
		JP 02975006 B2	10/11/1999
		JP 02981210 B2	22/11/1999
		JP 03017475 B2	06/03/2000
		JP 03046955 B2	29/05/2000
		JP 03068056 B2	24/07/2000
		JP 03079085 B2	21/08/2000
		JP 03154977 B2	09/04/2001
		JP 03184160 B2	09/07/2001
		JP 03204949 B2	04/09/2001
		JP 03219736 B2	15/10/2001
		JP 03224525 B2	29/10/2001
		JP 03247659 B2	21/01/2002
		JP 03317957 B2	26/08/2002
		JP 03419686 B2	23/06/2003
		JP 03445215 B2	08/09/2003
		JP 03462168 B2	05/11/2003
		JP 03488688 B2	19/01/2004
		JP 03557163 B2	25/08/2004
		JP 03557398 B2	25/08/2004
		JP 03572259 B2	29/09/2004
		JP 03655184 B2	02/06/2005
		JP 03672449 B2	20/07/2005
		JP 03725781 B2	14/12/2005
		JP 03837005 B2	25/10/2006
		JP 03842541 B2	08/11/2006
		JP 03857532 B2	13/12/2006
		JP 03880285 B2	14/02/2007
		JP 03880314 B2	14/02/2007
		JP 03895922 B2	22/03/2007
		JP 03930704 B2	13/06/2007
		JP 03971095 B2	05/09/2007
		JP 03971115 B2	05/09/2007
		JP 03971382 B2	05/09/2007
		JP 03971385 B2	05/09/2007
		JP 03978308 B2	19/09/2007
		JP 04025289 B2	19/12/2007
		JP 04038340 B2	23/01/2008
		JP 04041264 B2	30/01/2008
		JP 04046975 B2	13/02/2008
		JP 04071709 B2	02/04/2008
		JP 04080712 B2	23/04/2008
		JP 04102553 B2	18/06/2008

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/058650

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		JP 04139434 B2	27/08/2008
		JP 04252896 B2	08/04/2009
		JP 04290001 B2	01/07/2009
		JP 04393457 B2	06/01/2010
		JP 04437006 B2	24/03/2010
		JP 04484697 B2	16/06/2010
		JP 04489801 B2	23/06/2010
		JP 04542745 B2	15/09/2010
		JP 04549019 B2	22/09/2010
		JP 04571777 B2	27/10/2010
		JP 04571941 B2	27/10/2010
		JP 04574616 B2	04/11/2010
		JP 04616828 B2	19/01/2011
		JP 04638867 B2	23/02/2011
		JP 04689672 B2	25/05/2011
		JP 04705082 B2	22/06/2011
		JP 04758644 B2	31/08/2011
		JP 04773968 B2	14/09/2011
		JP 04787760 B2	05/10/2011
		JP 04791368 B2	12/10/2011
		JP 04917014 B2	18/04/2012
		JP 05006977 B2	22/08/2012
		JP 05091130 B2	05/12/2012
		JP 05139055 B2	06/02/2013
		JP 05156625 B2	06/03/2013
		JP 05165557 B2	21/03/2013
		JP 05179353 B2	10/04/2013
		JP 05183927 B2	17/04/2013
		JP 05202315 B2	05/06/2013
		JP 05248315 B2	31/07/2013
		JP 05301165 B2	25/09/2013
		JP 05335671 B2	06/11/2013
		JP 05357393 B2	04/12/2013
		JP 05367986 B2	11/12/2013
		JP 05433124 B2	05/03/2014
		JP 05489457 B2	14/05/2014
		JP 05590086 B2	17/09/2014
		JP 05597993 B2	01/10/2014
		JP 05613211 B2	22/10/2014
		JP 05680403 B2	04/03/2015
		JP 05745736 B2	08/07/2015
		JP 10-308547 A	17/11/1998
		JP 10-319195 A	04/12/1998
		JP 11-008431 A	12/01/1999
		JP 11-074601 A	16/03/1999
		JP 11-087810 A	30/03/1999
		JP 11-087829 A	30/03/1999
		JP 11-097768 A	09/04/1999
		JP 11-121370 A	30/04/1999
		JP 11-145543 A	28/05/1999

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/058650

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		JP 11-154642 A	08/06/1999
		JP 11-160513 A	18/06/1999
		JP 11-191648 A	13/07/1999
		JP 11-191653 A	13/07/1999
		JP 11-191660 A	13/07/1999
		JP 11-261148 A	24/09/1999
		JP 11-274610 A	08/10/1999
		JP 11-298084 A	29/10/1999
		JP 2000-004057 A	07/01/2000
		JP 2000-058944 A	25/02/2000
		JP 2000-077762 A	14/03/2000
		JP 2000-089011 A	31/03/2000
		JP 2000-114635 A	21/04/2000
		JP 2000-200933 A	18/07/2000
		JP 2000-294864 A	20/10/2000
		JP 2000-312048 A	07/11/2000
		JP 2000-340869 A	08/12/2000
		JP 2000-346999 A	15/12/2000
		JP 2000-353839 A	19/12/2000
		JP 2001-042098 A	16/02/2001
		JP 2001-044549 A	16/02/2001
		JP 2001-135879 A	18/05/2001
		JP 2001-135882 A	18/05/2001
		JP 2001-135883 A	18/05/2001
		JP 2001-148529 A	29/05/2001
		JP 2001-160644 A	12/06/2001
		JP 2001-168423 A	22/06/2001
		JP 2001-168430 A	22/06/2001
		JP 2001-168440 A	22/06/2001
		JP 2001-215721 A	10/08/2001
		JP 2001-267673 A	28/09/2001
		JP 2001-274488 A	05/10/2001
		JP 2001-274496 A	05/10/2001
		JP 2001-298233 A	26/10/2001
		JP 2001-308419 A	02/11/2001
		JP 2001-332794 A	30/11/2001
		JP 2002-026435 A	25/01/2002
		JP 2002-043667 A	08/02/2002
		JP 2002-043669 A	08/02/2002
		JP 2002-057386 A	22/02/2002
US 2011-0188014 A1	04/08/2011	CN 102119365 A	06/07/2011
		CN 102119365 B	05/06/2013
		JP 05732392 B2	10/06/2015
		JP 2011-530819 A	22/12/2011
		KR 10-2011-0055610 A	25/05/2011
		NL 2003310 A1	16/02/2010
		TW 201009513 A	01/03/2010
		TW I468874 B	11/01/2015
		US 9207548 B2	08/12/2015

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/058650

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		WO 2010-017892 A1	18/02/2010
US 2007-0080307 A1	12/04/2007	DE 102005048670 B3	24/05/2007
		JP 04328793 B2	09/09/2009
		JP 2007-129209 A	24/05/2007
		NL 1032562 A1	11/04/2007
		NL 1032562 C2	25/02/2008
		US 7755070 B2	13/07/2010
WO 2009-025557 A1	26/02/2009	CN 101785368 A	21/07/2010
		CN 101785368 B	02/01/2013
		CN 101785369 A	21/07/2010
		EP 2191698 A2	02/06/2010
		EP 2191698 B1	03/10/2012
		JP 05191541 B2	08/05/2013
		JP 05659015 B2	28/01/2015
		JP 2010-537377 A	02/12/2010
		JP 2010-537424 A	02/12/2010
		KR 10-1495208 B1	25/02/2015
		KR 10-1528581 B1	12/06/2015
		KR 10-2010-0063082 A	10/06/2010
		TW 200919112 A	01/05/2009
		TW I448828 B	11/08/2014
		US 2009-0250639 A1	08/10/2009
		US 2010-0253928 A1	07/10/2010
		US 7763871 B2	27/07/2010
		US 8242473 B2	14/08/2012
		WO 2009-024860 A2	26/02/2009
		WO 2009-024860 A3	16/04/2009