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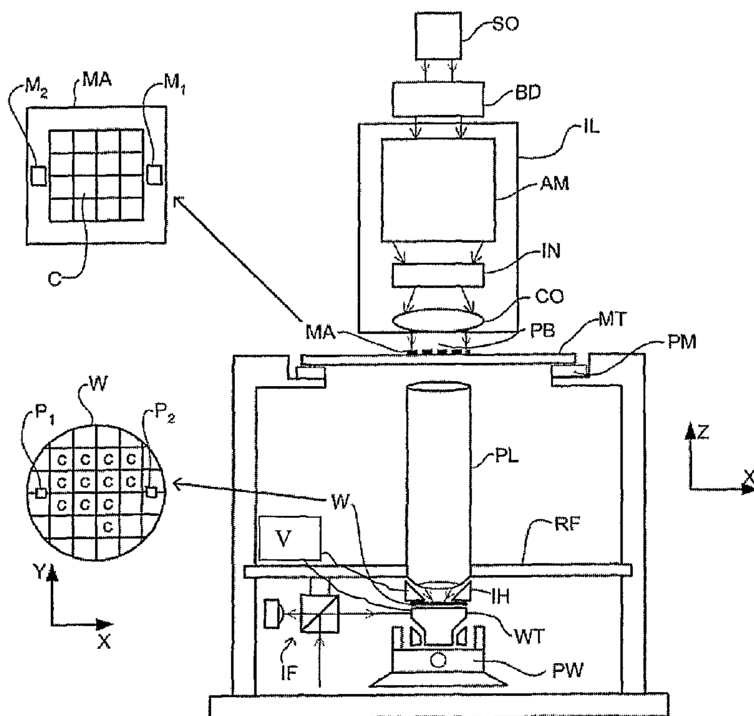
(54) **Title:** IMMERSION LIQUID, EXPOSURE APPARATUS, AND EXPOSURE PROCESS



(57) **Abstract:** An immersion liquid is provided comprising an ion-forming component, e.g. an acid or a base, that has a relatively high vapor pressure. Also provided are lithography processes and lithography systems using the immersion liquid.

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IMMERSION LIQUID, EXPOSURE APPARATUS, AND EXPOSURE PROCESS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to US application 11/071,044, filed on 3 March 2005, which claims the benefit of U.S. provisional application 60/651,513, filed on 10 February 2005. Both priority applications are hereby incorporated in their entirety by reference.

FIELD

[0002] The invention relates to immersion liquids; exposure apparatus, and exposure processes.

BACKGROUND

[0003] Immersion lithography is gaining attention due to improvements in critical dimensions and/or depth of focus that it provides. However, the technology also faces some concerns. For instance, on the one hand an ultra-pure immersion liquid may be advantageous to minimize the appearance of stains when drying areas wetted by the liquid, but on the other hand it may be desirable to include additives in the immersion liquid to influence or create desirable properties. E.g, it may be desirable to include acid components in the immersion liquid to avoid or minimize so-called T-topping or other undesirable effects. T-topping, for instance, may occur when a resist layer on a substrate to be exposed to radiation comes into contact with the immersion liquid and components in the resist (e.g. photo-acid generators) diffuse or dissolve into the immersion liquid. See also EP 1 482 372 A1.

[0004] Accordingly, objectives of the invention include providing an immersion liquid comprising one or more additives yet having reduced staining concerns.

[0005] Also, objectives of the invention include avoiding or minimizing streaming potential effects caused by the flow of immersion liquid (discussed in more detail infra).

SUMMARY

[0006] The invention provides immersion liquids, exposure apparatus, and exposure processes.

[0007] In an embodiment, the invention provides an immersion liquid formed by a method comprising adding an ion-forming component to a liquid (e.g. an aqueous liquid), wherein said ion-forming component has a vapor pressure greater than 0.1kPa, e.g. greater than water.

[0008] In an embodiment, the invention provides an immersion liquid having a pH below 7, said pH below 7 being at least partly caused by a component having a vapor pressure greater than 0.1 kPa, e.g. greater than water.

[0009] In an embodiment, the invention provides an immersion liquid having a pH greater than 7, said pH greater than 7 being at least partly caused by a component having a vapor pressure greater than 0.1 kPa, e.g. greater than water.

[00010] In an embodiment, the invention provides an immersion liquid having an electric conductivity of at least 0.1 µS/cm, e.g. at least 1.3 µS/cm at 25°C. In an embodiment, the invention provides an immersion liquid having an electric conductivity in the range of 0.1-100 µS/cm at 25°C, e.g. in the range of 1.3-100 µS/cm at 25°C. In an embodiment, the conductivity is at least partly caused by a component having a vapor pressure greater than 0.1 kPa, e.g. greater than water.

[00011] Also, the invention provides processes, e.g. an immersion lithography process, using the immersion liquids. In an embodiment, the invention provides a device manufacturing process comprising exposing a photosensitive substrate to radiation, wherein said radiation has passed through the immersion liquid prior to reaching said substrate.

[00012] In addition, the invention provides immersion lithography systems comprising an immersion lithography apparatus and one or more of the immersion liquids.

[00013] In an embodiment, the invention provides a process comprising:

(i) adding a component to a liquid, said component having a vapor pressure greater than 0.1 kPa, e.g. greater than water;

(ii) exposing a photosensitive substrate to radiation, wherein said radiation has passed through said aqueous liquid comprising said component prior to reaching said photosensitive substrate;

wherein said adding of said component increases the ion concentration in said liquid.

[00014] In an embodiment, the invention provides a process comprising:

(i) adding an acid to a liquid, said acid having a vapor pressure of at least 0.1kPa, e.g. at least 5kPa;

(ii) exposing a photosensitive substrate to radiation, wherein said radiation has passed through said liquid comprising said component prior to reaching said photosensitive substrate.

[00015] In an embodiment, the invention provides a process comprising:

(i) patterning a beam of radiation;

(ii) passing the patterned beam of radiation through a liquid (e.g. an aqueous liquid), said liquid comprising ions formed by a component having a vapor pressure greater than 0.1 kPa, the conductivity of said liquid being at least 0.25 µS/cm;

(iii) exposing a photosensitive substrate to the patterned beam of radiation.

[00016] In an embodiment, the invention provides an immersion lithography system comprising:

(i) an immersion lithography exposure apparatus; and

(ii) an immersion liquid, e.g. an immersion having an electric conductivity in the range of 0.1-100 µS/cm at 25°C (for instance in the range of 1.3-100 µS/cm at 25°C) or a carbon dioxide enriched immersion liquid.

[00017] In an embodiment, the invention provides a lithography apparatus having a voltage generator capable of applying a voltage difference between a first part of a lithography apparatus, e.g. a substrate table, and a second part of the lithography apparatus, e.g. an immersion hood of an immersion lithography apparatus. In an embodiment, the invention provides a process comprising applying a voltage difference between a first part of a lithography apparatus, e.g. the substrate table, and a second part of the lithography apparatus, e.g. the immersion hood of an immersion lithography apparatus.

[00018] Additional objects, advantages and features of the invention are set forth in this specification, and in part will become apparent to those skilled in the art on examination of the following, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[00019] Fig. 1 represents an immersion lithography system according to an embodiment of the invention.

[00020] Fig. 2 represents an embodiment of an immersion hood of an immersion lithography system according to an embodiment of the invention.

DETAILED DESCRIPTION

[00021] Preliminarily, this application at various instances refers to vapor pressures of components. In this regard, the vapor pressure of a component refers to the vapor pressure of a component in its pure form (thus not in a mixture or in solution) at 20°C.

[00022] In an embodiment, the invention provides an immersion liquid. Also, the invention provides a process using an immersion liquid, e.g. an immersion lithography process.

IMMERSION LIQUID

[00023] In an embodiment, the immersion liquid is prepared by a process comprising adding one or more components to a liquid, e.g. an aqueous liquid, for instance a liquid comprising, relative to the total weight of the liquid, at least 50wt%

water, such as at least 75wt% water, at least 90wt% water, at least 95wt% water, at least 99wt% water, at least 99.5wt% water, at least 99.9wt% water, or at least 99.99wt% water. In an embodiment, the liquid, before adding the one or more components, has an electric conductivity of less than 0.1 μS/cm (as determined at 25°C). In an embodiment, the liquid is de-gassed before adding the one or more components. In an embodiment, the liquid is purified before adding the one or more components. In an embodiment, the liquid is ultra-pure, de-gassed water.

[00024] In an embodiment, the component added to the liquid has a relatively high vapor pressure. A high vapor pressure may assist, e.g., in avoiding stains on a substrate when immersion liquid is removed (e.g., evaporated) from the substrate. In an embodiment, the component added to the liquid has a vapor pressure exceeding the vapor pressure of the liquid it is added to. In an embodiment, the component added to the liquid has a vapor pressure of at least 0.1 kPa, e.g. at least 0.25 kPa, at least 0.5 kPa, at least 0.75 kPa, at least 1 kPa, at least 1.3 kPa, at least 1.5 kPa, at least 1.8 kPa, at least 2.1 kPa, or exceeding the vapor pressure of water (i.e., exceeding 2.34 kPa). In an embodiment, the component added to the liquid has a vapor pressure of at least 3.5 kPa, such as at least 5kPa, at least 10kPa, at least 20kPa, at least 30kPa, or at least 50kPa. In an embodiment, the component being added is formic acid or acetic acid. In an embodiment, the component added to the liquid is, in its pure form at 20°C and at 1 atmosphere pressure, a gas. In an embodiment, the component added to the liquid is carbon dioxide. In an embodiment, the immersion liquid comprises, relative to the total weight of the immersion liquid, less than 5 wt% of components having a vapor pressure below 2.0kPa (e.g. below 1.5kPa, below 1 kPa, below 0.5kPa, below 0.25kPa, below 0.1 kPa, or 0kPa), e.g. less than 3 wt%, less than 1 wt%, less than 0.5 wt%, less than 0.25 wt%, less than 0.1wt%, less than 0.05wt%, less than 0.025 wt%, less than 0.01wt%, or less than 0.005wt%. In an embodiment, the immersion liquid comprising the component having a relatively high vapor pressure is, not taking into account the main constituent of the immersion liquid (e.g., water in an immersion liquid having water as the main constituent), essentially absent components having a vapor pressure below 2.0kPa, e.g. below 1.5kPa, below 1 kPa, below 0.5kPa, below 0.25kPa, below 0.1 kPa, or 0kPa.

[00025] In an embodiment, the component added to the liquid promotes conductivity of the liquid, e.g. by promoting ion formation. Increased conductivity of the immersion liquid may assist in decreasing or avoiding streaming potential concerns. Streaming potential is discussed in, e.g, the article "Streaming Potential Cells For The Study of Erosion-Corrosion Caused By Liquid Flow" by Varga and Dunne in J. Phys. D: Appl. Phys., 18 (1985), p.211-220. Streaming potential may, e.g., shorten the lifetime, for instance through corrosion or erosion, of e.g. coatings, sensors and/or (alignment) markers that come into contact with the flow of immersion liquid (in particular substantially conductive components of, e.g., coatings, sensors, and/or markers). In an embodiment, the conductivity of the liquid comprising the component is at least 0.1 μS/cm at 25°C, for instance at least 0.25 μS/cm, at least 0.5 μS/cm, at least 0.75 μS/cm, at least 1 μS/cm, at least 1.3 μS/cm, at least 1.5 μS/cm, at least 1.75 μS/cm, at least 2 μS/cm, at least 3 μS/cm, at least 5 μS/cm, at least 10 μS/cm, at least 25 μS/cm, or at least 50 μS/cm. While the above-mentioned and below-mentioned conductivities are determined at 25°C, the temperature at which the immersion liquid is used may be different. The values referred to, however, remain the conductivities as determined at 25°C.

[00026] While increased conductivity may assist in reducing or eliminating the effect of streaming potential, it may also increase the amount of component(s) that needs to be added to the immersion liquid, which may lead to staining or bubble concerns. In an embodiment, the conductivity of the liquid comprising the component is less than 50 mS/cm at 25°C, e.g. less than 25 mS/cm, less than 10 mS/cm, less than 5 mS/cm, less than 1 mS/cm, less than 500 μS/cm, less than 250 μS/cm, less than 150 μS/cm, less than 75 μS/cm, less than 50 μS/cm, less than 25 μS/cm, less than 15 μS/cm, less than 10 μS/cm, less than 7 μS/cm, less than 4 μS/cm, or less than 2 μS/cm. In an embodiment, the conductivity of the liquid is in the range of 0.1-100 μS/cm at 25°C, e.g. 0.25-25 μS/cm, 0.4-10 μS/cm, or 0.6-6 μS/cm. In one embodiment, the conductivity of the liquid, e.g. an aqueous liquid, for instance ultra-pure water, is increased by adding salts or acids to the liquid. In an embodiment, the liquid is enriched with acetic acid, formic acid, CO_2 (CO_2 may form in/with water the ions H^+ and HCO_3^-), or NH_3 (NH_3 may form in/with water the ions NH_4^+ and OH^-).

[00027] Also, streaming potential may be reduced or avoided by decreasing the speed and/or turbulence of the water flow. Furthermore, while not necessarily avoiding streaming potential itself, providing a voltage difference between the area effected by the streaming potential (e.g. the substrate table, for instance a sensor or a sensor plate on the substrate table) and another area may limit or negate the undesirable effects caused by the streaming potential. In an embodiment, the invention provides a lithography apparatus having a voltage generator capable of applying a voltage difference between a first part of a lithography apparatus, e.g. the substrate table, and a second part of the lithography apparatus, e.g. the immersion hood of an immersion lithography apparatus. In an embodiment, the invention provides a process comprising applying a voltage difference between a first part of a lithography apparatus, e.g. the substrate table, and a second part of the lithography apparatus, e.g. the immersion hood of an immersion lithography apparatus. In an embodiment, the voltage difference is at least 0.1V, for instance at least 0.25V, at least 0.5V, at least 1V, at least 2V, at least 3V, at least 4V, or at least 5V. In an embodiment, the voltage difference is less than 50V.

[00028] In an embodiment, the component added to the liquid is an acidic component, e.g. acetic acid, formic acid, or carbon dioxide. Acidity of the immersion liquid may assist in maintaining the effectiveness of resist that may come into contact with the immersion liquid, e.g. by helping to slow down/decrease diffusion or dissolution of photo-acid generators, that may be present in the resist, into the immersion liquid. In an embodiment, the liquid comprising the component has a pH below 7, e.g. below 6.5, below 6.0, below 5.5, below 5.0, below 4.5, or below 4.0. In an embodiment, the pH is at least 2.0, such as at least 2.5, at least 3.0, at least 3.5, at least 3.75, at least 4.0, at least 4.5, at least 5.0, or at least 5.5. In an embodiment, the component added to the liquid is a base, e.g ammonia (NH_3). Alkalinity of the immersion liquid may assist in maintaining the effectiveness of resist that may come into contact with the immersion liquid should the resist comprise alkaline components (bases) rather than acid components that may leak into the immersion liquid. In an embodiment, the liquid comprising the component has a pH above 7, e.g. above 7.5, above 8, above 8.5, above 9, above 9.5, or above 10. In an embodiment, the pH is below 14.

[00029] The manner of adding the (one or more) component(s) to the liquid may vary and may depend to an extent, e.g., on the type of component being added (e.g., whether it is available as a gas, a solid, or a liquid). In an embodiment, the component is added via diffusion through a membrane. For instance, the liquid may flow on one side of a membrane and the component on the other side of the membrane, whereby the membrane is impermeable to the liquid but permeable to the component, thus allowing the component to diffuse into liquid. In an embodiment, the component thus added is a gas, e.g. CO_2. In an embodiment, the component is added along with one or more inert gases, e.g. N_2. Accordingly, in an embodiment, a liquid (e.g. an aqueous liquid, for instance ultra-pure water) flows on one side of the membrane and a CO_2/N_2 mixture flows on the other side of the membrane, allowing CO_2 and N_2 to diffuse into the liquid. Commercial examples of suitable membrane equipment include, e.g., LIQUI-CEL membrane contactors from MEMBRANA. In an embodiment, the component is added to the liquid by flowing (e.g., dripping) the component into the liquid (or by flowing a comparatively concentrated component/liquid solution into the liquid; e.g., when the component is ammonia and the liquid is water, the ammonia may be added by flowing a comparatively concentrated aqueous ammonia solution into the water). The adding of the (one or more) component(s) may be done remote from the apparatus (the immersion liquid may be "pre-prepared"), the adding may be done in a separate unit that is linked to the apparatus (e.g., a water purification unit for the apparatus may be adapted for adding the one or more components), or the adding may be integrated into the apparatus.

PROCESS

[00030] The invention provides processes using the above-mentioned immersion liquids, for instance processes wherein a substrate is exposed to radiation and wherein the radiation passes through the immersion liquid before reaching the substrate.

[00031] In an embodiment, a process is provided comprising exposing a substrate to radiation, wherein said radiation has passed through an immersion liquid as described in the above section. In an embodiment, the process comprises

patterning a beam of radiation (e.g. with the aid of a reticle or an array of individually programmable elements), passing the patterned beam through a projection system (e.g. an array of lenses), passing the patterned beam through the immersion liquid, and exposing a portion of the substrate with the patterned beam. In an embodiment, the substrate is a semiconductor substrate, e.g. a semiconductor wafer. In an embodiment, the semiconductor substrate material is selected from the group consisting of Si, SiGe, SiGeC, SiC, Ge, GaAs, InP, and InAs. In an embodiment, the semiconductor substrate is a III/V semiconductor compound. In an embodiment, the semiconductor substrate is a silicon substrate. In an embodiment, the substrate is a glass substrate. In an embodiment, the substrate is a ceramic substrate. In an embodiment, the substrate is an organic substrate, e.g. a plastic substrate. In an embodiment, the substrate is a photosensitive substrate, e.g. by having coated the substrate with a layer of resist.

[00032] In an embodiment, a device manufacturing process is provided comprising:

(i) patterning a beam of radiation;

(ii) passing the patterned beam of radiation through an aqueous liquid, said aqueous liquid comprising ions formed by a component having a vapor pressure greater than 0.1 kPa;

(iii) exposing a photosensitive substrate to the patterned beam of radiation.

[00033] Also, in an embodiment, a process is provided comprising:

(i) patterning a beam of radiation;

(ii) passing the patterned beam of radiation through a liquid comprising an acid or a base, said acid or base having a vapor pressure exceeding the vapor pressure of said liquid;

(ii) exposing a photosensitive substrate to radiation, wherein said radiation has passed through said aqueous liquid comprising said component prior to reaching said photosensitive substrate.

[00034] In an embodiment, the process is a lithography process, such as an immersion lithography process. An example of an apparatus for carrying out an immersion lithography process is shown in Figure 1. The apparatus depicted in Figure 1 comprises:

[00035] an illumination system (illuminator) IL configured to condition a radiation beam PB (e.g. UV radiation or DUV radiation);

[00036] a support structure (e.g. a mask table) MT constructed to support a patterning device MA and connected to a first positioner PM configured to accurately position the patterning device in accordance with certain parameters. The support structure supports, i.e. bears the weight of, the patterning device. It holds the patterning device in a manner that depends on the orientation of the patterning device, the design of the lithographic apparatus, and other conditions, such as for example whether or not the patterning device is held in a vacuum environment. The support structure can use mechanical, vacuum, electrostatic or other clamping techniques to hold the patterning device. The support structure may be a frame or a table, for example, which may be fixed or movable as required. The support structure may ensure that the patterning device is at a desired position, for example with respect to the projection system. The term "patterning device" used herein should be broadly interpreted as referring to any device that can be used to impart a radiation beam with a pattern in its cross-section such as to create a pattern in a target portion of the substrate. It should be noted that the pattern imparted to the radiation beam may not exactly correspond to the desired pattern in the target portion of the substrate, for example if the pattern includes phase-shifting features or so called assist features. Generally, the pattern imparted to the radiation beam will correspond to a particular functional layer in a device being created in the target portion, such as an integrated circuit. The patterning device may be transmissive or reflective. Examples of patterning devices include masks and arrays of individually programmable elements (e.g., programmable mirror arrays or programmable LCD panels). Masks are well known in lithography, and include mask types such as binary, alternating phase-shift, and attenuated phase-shift, as well as various hybrid mask types. An example of a programmable mirror array employs a matrix arrangement of small mirrors, which can be individually tilted so as to reflect an incoming radiation beam in different

directions. The tilted mirrors impart a pattern in a radiation beam which is reflected by the mirror matrix.

[00037] a substrate table (e.g. a wafer table) WT constructed to hold a substrate (e.g. a resist-coated wafer) W and connected to a second positioner PW configured to accurately position the substrate in accordance with certain parameters. In an embodiment, the wafer table comprises one or more sensors (not shown), e.g. an image sensor (for instance a transmission image sensor), a dose sensor, and/or an aberration sensor. In an embodiment, one or more of the sensors comprise one or more metals, e.g. chromium. In an embodiment, one or more of the sensors are coated, e.g. with titanium nitride.

[00038] a projection system (e.g., a refractive projection lens system) PL configured to project a pattern imparted to the radiation beam PB by patterning device MA onto a target portion C (e.g. comprising one or more dies) of the substrate W.

[00039] The illumination system may include various types of optical components, such as refractive, reflective, magnetic, electromagnetic, electrostatic or other types of optical components, or any combination thereof, for directing, shaping, or controlling radiation. The term "projection system" used herein should be broadly interpreted as encompassing any type of projection system, including refractive, reflective, catadioptric, magnetic, electromagnetic and electrostatic optical systems, or any combination thereof, as appropriate for the exposure radiation being used, or for other factors such as the use of the immersion liquid or the use of a vacuum. In an embodiment, the projection system includes an array of lenses. In an embodiment, the apparatus comprises an array of projection systems, e.g. to increase throughput.

[00040] As here depicted, the apparatus is of a transmissive type (e.g. employing a transmissive mask). Alternatively, the apparatus may be of a reflective type (e.g. employing a programmable mirror array of a type as referred to above, or employing a reflective mask).

[00041] The lithographic apparatus may be of a type having two (dual stage) or more substrate tables (and/or two or more mask tables). In such "multiple stage" machines the additional tables may be used in parallel, or preparatory steps may be

carried out on one or more tables while one or more other tables are being used for exposure.

[00042] Referring to Figure 1, the illuminator IL receives a radiation beam from a radiation source SO. The source and the lithographic apparatus may be separate entities, for example when the source is an excimer laser. In such cases, the source is not considered to form part of the lithographic apparatus and the radiation beam is passed from the source SO to the illuminator IL with the aid of a beam delivery system BD comprising, for example, suitable directing mirrors and/or a beam expander. In other cases the source may be an integral part of the lithographic apparatus, for example when the source is a mercury lamp. The source SO and the illuminator IL, together with the beam delivery system BD if required, may be referred to as a radiation system. In an embodiment, the radiation provided by radiation source SO has a wavelength of at least 50 nm, e.g. at least 100nm, at least 150nm, at least 175nm, at least 200nm, at least 225nm, at least 275nm, at least 325nm, at least 350nm, or at least 360nm. In an embodiment, the radiation provided by radiation source SO has a wavelength of at most 450nm, e.g. at most 425nm, at most 375nm, at most 360nm, at most 325nm, at most 275nm, at most 250nm, at most 225nm, at most 200nm, or at most 175nm. In an embodiment, the radiation has a wavelength of 365nm, 355nm, 248nm, or 193 nm.

[00043] The illuminator IL may comprise an adjuster AD for adjusting the angular intensity distribution of the radiation beam. Generally, at least the outer and/or inner radial extent (commonly referred to as σ-outer and σ-inner, respectively) of the intensity distribution in a pupil plane of the illuminator can be adjusted. In addition, the illuminator IL may comprise various other components, such as an integrator IN and a condenser CO. The illuminator may be used to condition the radiation beam, to have a desired uniformity and intensity distribution in its cross-section.

[00044] The radiation beam PB is incident on the patterning device MA, which is held by the support structure MT, and is patterned by the patterning device. Having traversed the patterning device, the radiation beam PB passes through the projection system PL, which focuses the beam onto a target portion C of the substrate W. An

immersion hood IH, which is described further below, supplies immersion liquid to a space between the final element of the projection system PL and the substrate W. In an embodiment, the substrate table WT and immersion hood IH are connected to a voltage generator V (e.g., a battery) that is capable of providing a voltage difference between the substrate table WT and the immersion hood IH (e.g. between a sensor plate of substrate table WT and the immersion hood IH).

[00045] With the aid of the second positioner PW and position sensor IF (e.g. an interferometric device, linear encoder or capacitive sensor), the substrate table WT can be moved accurately, e.g. so as to position different target portions C in the path of the radiation beam PB. Similarly, the first positioner PM and another position sensor (which is not explicitly depicted in Figure 1) can be used to accurately position the patterning device MA with respect to the path of the radiation beam PB, e.g. after mechanical retrieval from a mask library, or during a scan. In general, movement of the support structure MT may be realized with the aid of a long-stroke module (coarse positioning) and a short-stroke module (fine positioning), which form part of the first positioner PM. Similarly, movement of the substrate table WT may be realized using a long-stroke module and a short-stroke module, which form part of the second positioner PW. In the case of a stepper (as opposed to a scanner) the support structure MT may be connected to a short-stroke actuator only, or may be fixed. Patterning device MA and substrate W may be aligned using alignment marks M1, M2 and substrate alignment marks P1, P2. Although the substrate alignment marks as illustrated occupy dedicated target portions, they may be located in spaces between target portions (these are known as scribe-lane alignment marks).

[00046] Similarly, in situations in which more than one die is provided by the patterning device MA, the alignment marks may be located between the dies.

[00047] The depicted apparatus could be used in at least one of the following modes:

[00048] 1. In step mode, the support structure MT and the substrate table WT are kept essentially stationary, while an entire pattern imparted to the radiation beam is projected onto a target portion C at one time (i.e. a single static exposure). The substrate table WT is then shifted in the X and/or Y direction so that a different target

portion C can be exposed. In step mode, the maximum size of the exposure field limits the size of the target portion C imaged in a single static exposure.

[00049] 2. In scan mode, the support structure MT and the substrate table WT are scanned synchronously while a pattern imparted to the radiation beam is projected onto a target portion C (i.e. a single dynamic exposure). The velocity and direction of the substrate table WT relative to the support structure MT may be determined by the (de-)magnification and image reversal characteristics of the projection system PL. In scan mode, the maximum size of the exposure field limits the width (in the non-scanning direction) of the target portion in a single dynamic exposure, whereas the length of the scanning motion determines the height (in the scanning direction) of the target portion.

[00050] 3. In another mode, the support structure MT is kept essentially stationary holding a programmable patterning device, and the substrate table WT is moved or scanned while a pattern imparted to the radiation beam is projected onto a target portion C. In this mode, generally a pulsed radiation source is employed and the programmable patterning device is updated as required after each movement of the substrate table WT or in between successive radiation pulses during a scan. This mode of operation can be readily applied to maskless lithography that utilizes programmable patterning device, such as a programmable mirror array of a type as referred to above.

[00051] Combinations and/or variations on the above described modes of use or entirely different modes of use may also be employed.

[00052] Figure 2 illustrates an embodiment of an immersion hood IH. Immersion Hood 10 forms a contactless seal to the substrate around the image field of the projection system so that immersion liquid 11 is confined to fill a space between the substrate surface and the final element of the projection system. The reservoir is formed by a seal member 12 positioned below and surrounding the final element of the projection system PL. Immersion liquid 11 is brought into the space below the projection system and within the seal member 12. The seal member 12 extends a little above the final element of the projection system and the liquid level rises above the final element so that a buffer of liquid is provided. The seal member 12 has an inner

periphery that at the upper end, in an embodiment, closely conforms to the shape of the projection system or the final element thereof and may, e.g., be round. At the bottom, the inner periphery closely conforms to the shape of the image field, e.g., rectangular though this need not be the case.

[00053] The immersion liquid 11 is confined in the immersion hood 10 by a gas seal 16 between the bottom of the seal member 12 and the surface of the substrate W. The gas seal is formed by gas, e.g. air or synthetic air but, in an embodiment, N_2 or an inert gas, provided under pressure via inlet 15 to the gap between seal member 12 and substrate and extracted via first outlet 14. The overpressure on the gas inlet 15, vacuum level on the first outlet 14 and geometry of the gap are arranged so that there is a high-velocity gas flow inwards that confines the liquid.

PRODUCTS

[00054] Some examples of devices that can be created with the present process and system include, e.g., micro electromechanical systems ("MEMS"), thin film heads, integrated passive components, image sensors, integrated circuits ("ICs") - including, e.g., power ICs, analog ICs, and discrete ICs -, and liquid crystal displays.

[00055] Having described specific embodiments of the invention, it will be understood that many modifications thereof will readily appear or may be suggested to those skilled in the art, and it is intended therefore that this invention is limited only by the spirit and scope of the following claims.

What is claimed is:

1. A device manufacturing process comprising:

(i) adding a component to a liquid, said component having a vapor pressure greater than 0.1 kPa;

(ii) exposing a photosensitive substrate to radiation, wherein said radiation has passed through said aqueous liquid comprising said component prior to reaching said photosensitive substrate;

wherein said adding of said component increases the ion concentration in said liquid.

2. The process of claim 1, wherein said component has a vapor pressure greater than water.

3. The process of claim 1 or 2, wherein said component lowers the pH of said liquid.

4. The process of claim 1 or 2, wherein said component raises the pH of said liquid.

5. The process of any one of the preceding claims, wherein said component has a vapor pressure of at least 1 kPa.

6. The process of any one of the preceding claims, wherein said liquid comprises, relative to the total weight of said liquid, at least 90wt% of water.

7. The process of any one of the preceding claims, wherein said liquid comprises, relative to the total weight of said liquid, at least 99.9wt% of water.

8. The process of any one of the preceding claims, wherein said component is a gas at 20°C and atmospheric pressure.

9. The process of any one of the preceding claims, wherein said liquid comprising said component has a pH in the range of 4.5-6.0.

10. The process of any one of the preceding claims, wherein said component is carbon dioxide or ammonia.

11. The process of any one of the preceding claims, wherein said liquid comprising said component is essentially absent components having a vapor pressure lower than 2.0kPa.

12. The process of any one of the preceding claims, wherein said substrate is a semiconductor wafer coated with a layer of resist.

13. The process of any one of the preceding claims, wherein said radiation is UV radiation having a wavelength in the range of 175nm-375nm.

14. The process of any one of the preceding claims, further comprising passing said radiation through an array of lenses prior to passing said radiation through said liquid comprising said component.

15. The process of any one of the preceding claims, further comprising patterning said radiation prior to passing said radiation through said liquid comprising said component.

16. The process of claim 15, wherein said patterning is effected with a mask or an array of individually programmable elements.

17. The process of any one of the preceding claims, wherein said photosensitive substrate rests on a substrate table during said exposing, said substrate table comprising a sensor, said sensor comprising titanium nitride and/or a metal.

18. The process of any one of the preceding claims, comprising adding at least 2 components having a vapor pressure of at least 0.1 kPa to said liquid.

19. A device manufactured with the process of any one of the preceding claims.

20. The device of claim 19, wherein said device is an integrated circuit.

21. A device manufacturing process comprising:

(i) adding an acid or base to a liquid, said acid or base having a vapor pressure of at least 0.1 kPa;

(ii) exposing a photosensitive substrate to radiation, wherein said radiation has passed through said liquid comprising said component prior to reaching said photosensitive substrate.

22. The process of claim 21, comprising adding an acid to said liquid.

23. The process of claim 21, comprising adding a base to said liquid.

24. A device manufacturing process comprising:

(i) patterning a beam of radiation;

(ii) passing the patterned beam of radiation through a liquid, said liquid comprising ions formed by a component having a vapor pressure greater than 0.1 kPa, the conductivity of said aqueous liquid being at least 0.25 µS/cm (as determined at 25°C); and

(iii) exposing a photosensitive substrate to the patterned beam of radiation.

25. An immersion lithography system comprising:

(i) an immersion lithography exposure apparatus; and

(ii) an immersion liquid having an electric conductivity in the range of 1.3-100 µS/cm (as determined at 25°C).

26. The system of claim 25, wherein said conductivity is at least 5 µS/cm.

27. The system of claim 25 or 26, wherein said conductivity is at most 50 µS/cm.

28. The system of claim 25, wherein said conductivity is in the range of 2-10 μS/cm.

29. The system of any one of claims 25-28, wherein said immersion liquid is formed by adding a salt, a base, or an acid to an aqueous liquid.

30. The system of any one of claims 25-29, wherein said immersion liquid comprises carbon dioxide.

31. The system of any one of claims 25-30, wherein said immersion liquid has a pH below 6.0.

32. The system of any one of claims 25-31, wherein said immersion lithography exposure apparatus includes a substrate table having a sensor comprising chromium and/or titanium nitride.

33. The system of any one of claims 25-32, wherein said conductivity is caused at least in part by a component having a vapor pressure greater than 5kPa.

34. A lithography apparatus having a voltage generator functionally connected to a first part of a lithography apparatus, said first part being a substrate table, and functionally connected to a second part of the lithography apparatus, said voltage generator being capable of establishing a voltage difference between said first part and said second part.

35. The apparatus of claim 34, wherein said apparatus is an immersion lithography apparatus and said second part is an immersion hood.

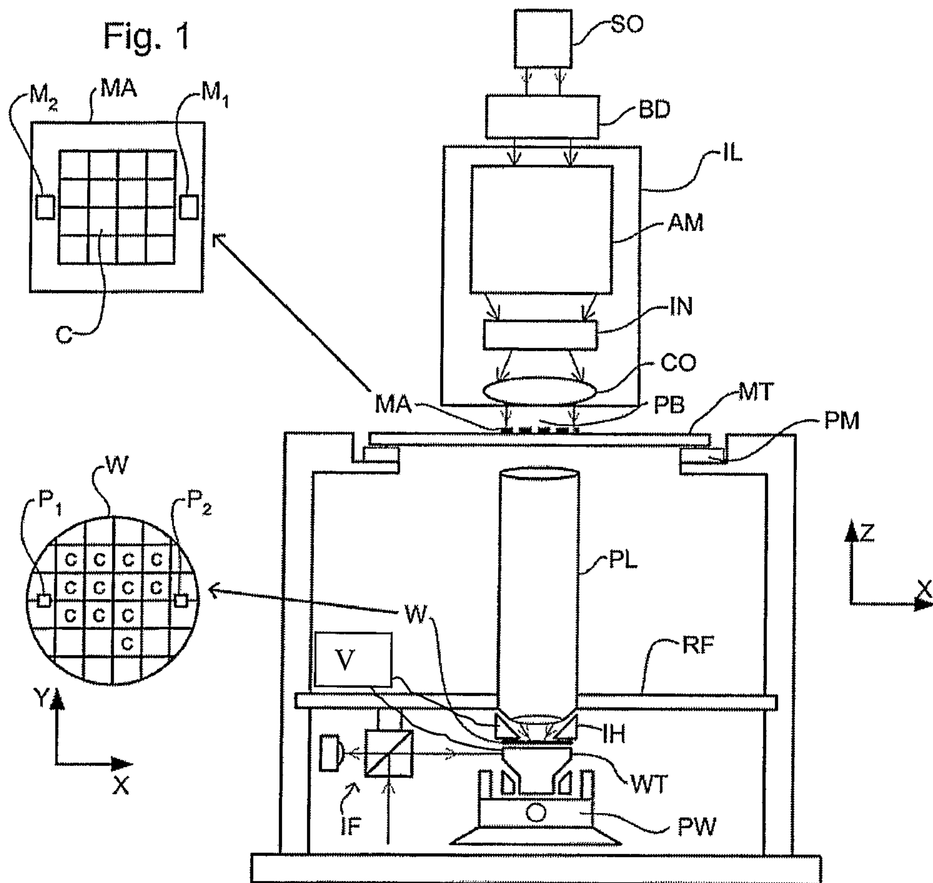
Fig. 1
SO
BD
IL
AM
IN
CO
MA
PB
MT
PM
M2
MA
M1
C
W
P1
P2
c
PL
Z
X
W
RF
V
IH
WT
PW
IF
Y
X

Fig. 2