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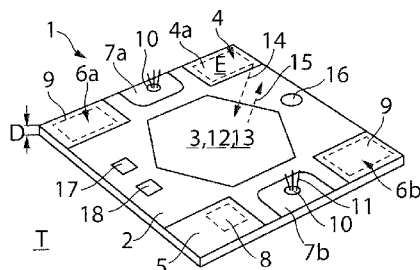
(54) Title: CLEANING DEVICE FOR AN EUV LITHOGRAPHY SYSTEM, EUV LITHOGRAPHY SYSTEM WITH SUCH A
DEVICE AND CLEANING METHOD

Fig. 2a

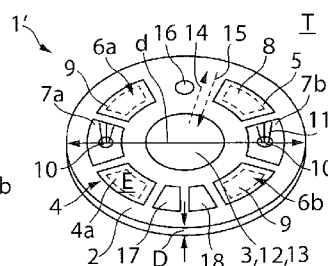


Fig. 2b

(57) Abstract: The invention relates to a cleaning device (1, 1') with a geometry adapted for mounting on a mask holder (RH) of an exposure mask (M) or for mounting on a wafer holder (WH) of a wafer (W) of an EUV lithography system (101), comprising: a providing device (3) for providing electrical energy, and also at least one cleaning unit (4, 5, 6a, b, 7a, b) for acting, in particular contactlessly, on particles in the environment of the cleaning device (1, 1'), the cleaning unit (4, 5, 6a, b, 7a, b) being in connection with the providing device (3) for the drawing of electrical energy. The invention also relates to an EUV lithography system with a cleaning device (1, 1') that is formed as described above and also to a method for cleaning an EUV lithography system.

Cleaning device for an EUV lithography system, EUV lithography system with
5 such a device and cleaning method

Reference to related application

This application claims the priority of the German Patent Application DE 10
10 2015 204 521.8 of 12 March 2015, the entire disclosure content of which is
incorporated by reference in the content of this application.

Background of the invention

15 The invention relates to a cleaning device for use in an EUV lithography system
that has a geometry adapted for mounting on a mask holder of an exposure
mask or for mounting on a wafer holder of a wafer of the EUV lithography
system. The invention also relates to an EUV lithography system with such a
cleaning device and to a method for cleaning an EUV lithography system, in
20 particular for cleaning a mask holder of an exposure mask or a wafer holder of a
wafer in an EUV lithography system.

For the purposes of this application, an EUV lithography system is understood as meaning an optical system for EUV lithography, i.e. an optical system that can be used in the field of EUV lithography. Apart from an EUV lithography apparatus, which serves for the production of semiconductor components, the optical system may be for example an inspection system for the inspection of an exposure mask used in an EUV lithography apparatus (hereinafter also referred to as a reticle or mask), for the inspection of a semiconductor substrate to be structured (hereinafter also referred to as a wafer) or a metrology system, which is used for measuring an EUV lithography apparatus or parts thereof, for example for measuring a projection system.

Microlithographic projection exposure apparatuses, from here on referred to as lithography apparatuses for short, generally consist of a light source, an illumination system converting the light rays emitted from the light source into illumination light, an object to be projected, which is referred to as the reticle or exposure mask, a projection lens, which projects an image of an object field onto an image field, and a further object, which is projected onto and is referred to as the wafer or substrate. The mask, or at least part of the mask, is located in the object field and the wafer, or at least part of the wafer, is located in the image field of the projection lens.

The best imaging resolutions at present are achieved by so-called EUV lithography apparatuses with a source of weak x-radiation at a wavelength of the illumination light of for example about 13.5 nm. The mask to be imaged, which is also referred to hereinafter as the exposure mask, generally comprises a glass substrate such as ULETM oder Zerodur®, which becomes highly reflective for light of a wavelength of 13.5 nm by a stack of dielectric layers, for example alternating Mo and Si layers, and also a mask structure, which is formed as a structured absorber layer on the stack of layers.

The path of rays of the EUV radiation in the EUV lithography apparatus typically runs completely in a vacuum and the mask holder or the mask stage (reticle stage) and also the illumination system, the projection lens and the wafer holder (wafer stage) are also typically arranged in a vacuum environment. To allow
5 different exposure masks or different wafers to be brought to a respective exposure position in the EUV lithography apparatus at which the object field or the image field is formed, an EUV lithography apparatus typically has a transporting device for transporting the exposure mask or the wafer. The transporting of the exposure mask or the wafer between the exposure position
10 and further positions within the EUV lithography apparatus typically takes place under vacuum conditions.

US 2011/0159440 A1 discloses a cleaning mask which serves for cleaning a mask holder that is arranged at an exposure position of an EUV lithography
15 apparatus. The mask holder is formed as an electrostatic chuck, which holds the cleaning mask or an exposure mask on the rear side with the aid of an electrostatic force of attraction. When there is contact between the chuck and the mask, abrasion occurs in the form of particles between the surface of the chuck and the rear side of the mask. It is proposed in US 2011/0159440 A1 to
20 use for removing the particles a so-called cleaning mask, which has on its rear side a particle catching layer, which is pressed against the surface of the chuck. The particle catching layer may for example comprise a layer of adhesive. The transporting of the cleaning mask through the EUV lithography apparatus takes place in the same way as in the case of a conventional exposure mask, i.e. the
25 vacuum in the EUV lithography apparatus does not have to be broken for the cleaning mask to be transported.

US 2012/0024318 A1 describes a cleaning device for a mask holder. The cleaning device has a substrate with a geometry that allows the cleaning device
30 to be transported to the mask holder for an exposure mask of the EUV lithography apparatus. Formed on the rear side of the cleaning device is a layer

of adhesive, which is pressed against the mask holder in order to take up particles that have been deposited on the mask holder.

US 2014/0226136 A1 also describes a cleaning device for cleaning equipment
5 for transporting and/or placing a reticle. The cleaning device comprises a substrate, which substantially has the form factor of the reticle that is transported and placed by the equipment. Attached to the substrate is at least one cleaning pad, which serves the purpose of transferring contaminants and/or particles from the equipment for transporting and placing the reticle to the
10 cleaning pad when the cleaning device comes into contact with the equipment.

WO 2014/032887 A1 describes methods and devices for the removal of particles from the surface of an object in a lithography apparatus. In WO 2014/032887 A1, it is proposed to bring a tape with a cleaning layer, in
15 particular a sticky layer, into contact with the surface to be cleaned, in order to transfer the particles from the surface to the tape.

In the case of EUV lithography systems, for example in the case of EUV lithography apparatuses and actinic metrology systems for mask inspection,
20 extremely stringent requirements are imposed on the mask with respect to defects. In the case of an EUV lithography apparatus, an image of particles that are deposited in a region of the mask that is to be imaged is projected onto every exposed wafer, and can therefore possibly make the entire mask unusable. A way in which contaminants often get onto the mask is that the
25 environment of the mask holder is contaminated, and a transfer of the contaminants onto the mask subsequently takes place. Although the production of particles is intended to be avoided in this application area, particles may nevertheless be formed in undesired or uncontrolled processes. During handling, i.e. the transporting, of a mask in an EUV lithography system, not only
30 is there possibly undesired particle formation or the occurrence of contaminants in the region of the mask holder or the wafer holder but also particles that may

have an adverse influence on the exposure process may be produced at all of the places at which the mask or the wafer comes into contact with components of the EUV lithography system.

5 Object of the invention

The object of the invention is to improve a cleaning device for an EUV lithography system, an EUV lithography system with such a cleaning device and also a method for cleaning an EUV lithography system in their properties, in particular in their cleaning effect.

Subject matter of the invention

This object is achieved by a cleaning device of the type mentioned in the introduction, comprising: a providing device for providing electrical energy, and also at least one cleaning unit for acting, in particular contactlessly, on particles in the environment of the cleaning device, the cleaning unit being in connection with the providing device for the drawing of electrical energy.

20 The inventors have realized that it is advantageous if a cleaning device which can be transported by means of a transporting device for an exposure mask or for a wafer of an EUV lithography system can be used not only on the mask holder or the wafer holder itself brought to an exposure position but possibly also for the cleaning at other positions and on other components of the EUV lithography system, without the cleaning device having to be exchanged for this purpose, as is the case with the cleaning devices described further above.

The components that should likewise be cleaned may be in particular mounting elements of a transporting device on which the mask or the wafer or the cleaning device taking the form of a mask or the form of a wafer is mounted or held during transport.

To be able to carry out cleaning a number of times by means of the cleaning device, one or more of the cleaning units may be supplied with electrical energy with the aid of the providing device, in order to actively clean those components that come into contact with the exposure mask / the wafer or with the cleaning device. The providing device may be in particular a possibly chargeable or exchangeable battery or a voltage source that allows power to be supplied to the cleaning units if they are to be activated. The providing device or the battery may also be a capacitor in which the electrical energy is stored. The storage of electrical energy in the battery or in the capacitor may take place before the introduction of the cleaning device into an EUV lithography system or possibly in the EUV lithography system at a charging station provided for this. The charging station may be arranged at a cleaning position or at another position in the EUV lithography system. The providing device may have an interface to such a charging station. The providing device, for example in the form of a battery or capacitor, may alternatively not have an interface with the outside, i.e. there are no electrical connections to components that are outside the cleaning device, so that the cleaning device operates fully autonomously.

The providing device may possibly itself be formed as an interface, which establishes a connection between a respective cleaning unit and an external energy source, for example a voltage source, arranged outside the cleaning device, in order to supply the respective cleaning unit with electrical energy. Such an energy source may for example be arranged at a cleaning position in the EUV lithography system, in particular at an exposure position. For example, the providing device may be designed to produce an electrical connection between a mask holder (for example an electrostatic reticle chuck) or a wafer holder and a cleaning unit, in that at least one contact element, for example in the form of a burl, which is provided on the mask holder or on the wafer holder, contacts an electrical connecting line of the providing device that is in electrical connection with the cleaning unit. The electrical connecting line may for

example connect a first side of the cleaning device, which in an exposure position is in contact with the mask holder or with the wafer holder or with the contact element or elements, to a second side of the cleaning device, which is facing away from the mask holder or the wafer holder and on which at least one
5 cleaning unit is mounted.

It has proven to be advantageous in particular if, unlike in the case of the cleaning devices or cleaning masks described above, the particles present in the environment of the cleaning device are acted on contactlessly, since in this
10 way the particles can be detached particularly easily from the surfaces on which they have been deposited.

The cleaning device is designed to be transported through the EUV lithography system with the aid of the same transporting device with which a conventional
15 exposure mask or a conventional wafer is also transported through the EUV lithography system. For this purpose, the dimensions of the cleaning device coincide with those of a conventional exposure mask or a conventional wafer. The weight of the cleaning device should also coincide substantially with the weight of a conventional exposure mask or a conventional wafer, in order to
20 avoid problems when transporting the cleaning device. If the cleaning device is designed for mounting on a mask holder, it is typically formed rectangularly or cuboidally, its basic dimensions (length, height and width) coinciding with those of a conventional exposure mask. If the cleaning device is designed for mounting on a wafer holder, it is typically formed circularly, its basic dimensions
25 (diameter and height) coinciding with those of a conventional wafer.

Transporting by means of the transporting device allows the time period required for the cleaning, in which no process, i.e. for example exposure or measurements or inspection, can be carried out in the EUV lithography system,
30 to be significantly reduced, since the vacuum does not have to be broken for the cleaning. The cleaning may also be carried out while exposure is in progress or

while measurements, for example investigations of structures on the exposure mask or on the wafer, are in progress, so that the time period during which the process is interrupted can be reduced further.

- 5 There are a number of possibilities for the (contactless) cleaning or the contactless action on particles that are present in the EUV lithography system, in particular deposited on the surfaces, with the aid of a cleaning unit.

In one embodiment, the cleaning unit has at least one field generating device
10 for generating an electrostatic field. In this embodiment, a field generating device that generates an electrostatic field, for example between two plates or between two or more conductor tracks, is provided. The electrostatic field may serve for generating a (negative) direct voltage on an electrostatically chargeable structure, which may for example take the form of a plastic and in
15 which one or more current-conducting conductor tracks are integrated. The electrostatically chargeable structure attracts dielectric particles, for example dust, that are present in the environment of the cleaning device and securely holds them on the surface of the cleaning device while the field generating device is active.

20 In a development, the field generating device has at least one electrode, preferably at least two electrodes, for generating the electrostatic field. The at least one electrode is typically formed either on the side of the cleaning device that is facing away from the mask holder or the wafer holder and/or is mounted
25 along the peripheral edge or along the side faces of the cleaning device. If a single electrode is formed on a respective surface, it typically serves for generating an electrical field between the cleaning device and electrically conductive components that are present in the environment of the cleaning device, which may for example be vacuum components, for example of
30 aluminium. If two or more electrodes are formed on a surface of the cleaning device, an electrical field may also be generated between these electrodes,

these electrodes not necessarily having to be at a different electrical potential in the case of generating an inhomogeneous electrostatic field (see below).

In an advantageous development, the field generating device is designed for
5 generating an inhomogeneous electrostatic field, the electrical field strength of the inhomogeneous electrical field preferably having the greatest absolute value or the highest field strength in the region of the cleaning device or at the electrode(s) of the field generating device. The use of an inhomogeneous electrostatic field is advantageous, since particles, for example in the form of
10 flakes, that have a high aspect ratio have a high induced dipole moment in an inhomogeneous electrostatic field. In the case of a particle in an inhomogeneous electrostatic field, the force resulting from the induced dipole moment is always directed in the direction of the higher field strength. If the inhomogeneous electrostatic field has the greatest field strength at the cleaning
15 device or the electrodes, the particles are deposited on the cleaning device, typically in the region of the electrode(s) of the cleaning device.

In a further development, at least one electrode projects beyond a planar surface of the cleaning device. As described further above, the cleaning device
20 typically has a plate-shaped main body, with the dimensions of a mask or a wafer. The plate-shaped main body has a first flat side and a second flat side, which are aligned parallel to one another. An electrode projecting beyond such a flat side or planar surface of the cleaning device typically generates an inhomogeneous electrostatic field. In particular, the electrode itself may have a
25 geometry that promotes the generation of an inhomogeneous electrostatic field. For example, the electrode may take the form of needles, burls, points or the like, which allow the production of local electrical field gradients in order to make possible the removal of particles from contaminated surfaces by induced electrical polarization or by electrostatic forces. The electrode(s) projecting
30 beyond the planar surface is/are typically electrically insulated from the rest of the planar surface in order to promote a strong inhomogeneity of the electrical

field strength. The electrode(s) preferably deviate(s) from a planar or flat geometry.

In a further embodiment, the cleaning unit has at least one actuator for generating vibrations. The actuator may be in particular an ultrasound transmitter for generating ultrasound waves, which can serve for the detachment of particles on surfaces that are present in the environment of the cleaning device.

In one embodiment, the cleaning unit has at least one cooling and/or heating device. A cooling device produces a lower temperature at the cleaning device in comparison with the environment. The cooling device may serve the purpose of bringing about a temperature gradient between the cleaning device and surfaces arranged in the environment of the cleaning device. The cooling device may in this way produce a thermophoresis, in which particles that have been deposited on the warmer surfaces in the environment diffuse to the colder surface of the cleaning device. Also in this case, the particles can be held on the cleaning device as long as the cooling device remains switched on. The cooling device may be for example a Peltier element. Alternatively or in addition, a heating device may also possibly be provided on the cleaning device.

In a further embodiment, the cleaning unit has at least one nozzle for the discharging of a cleaning gas. The cleaning gas, for example in the form of compressed air or an inert gas, for example nitrogen, may be directed onto the surfaces that are present in the environment of the cleaning device, in order to detach particles adhering there. The cleaning gas, to be more precise a connection to a supply line for feeding in the cleaning gas, may be provided at various, predetermined positions in the EUV lithography system at which cleaning is to take place, for example at the exposure position. The cleaning device may be connected to the supply line at the respective positions by way

of a connection, in order to feed the cleaning gas to the nozzle and thus direct it onto the surfaces to be cleaned. This is advantageous because a nozzle that makes selective local cleaning possible in the vicinity of the mask or the wafer cannot be arranged in the installation space that is kept free for the mask or for the wafer. The connection of the gas connection of the cleaning unit to the supply line may be established for example with the aid of the providing device, which possibly acts on a mechanically movable component in order to establish a gastight connection between the connection and the supply line. It is alternatively possible to integrate in the cleaning device a gas reservoir, in which a liquefied cleaning gas is possibly provided, in order to allow it to flow out through the nozzle as and when required.

In a further embodiment, the cleaning device comprises a receiver for receiving control signals of the EUV lithography system and/or a transmitter for transmitting measurement data of the cleaning device to the EUV lithography system. As already indicated further above, it is not necessary, and generally also not desired, for the cleaning unit to be permanently activated while the cleaning device is being transported through the EUV lithography system

The receiver, which may be formed in particular as a radio receiver, is designed for receiving control signals, which may for example signal to the cleaning device that, or at which point in time, a cleaning unit is to be activated or switched off. The activation of the cleaning unit(s) should generally only take place when certain positions of the cleaning device in the EUV lithography system are reached. The reaching of such a position may be detected by a control device of the EUV lithography system and this information can be transmitted to the cleaning device by way of a transmitter that is in connection with the control device. The information on reaching a certain position of the cleaning device in the EUV lithography system may for example be made available by the transporting device for transporting the exposure mask.

If a number of cleaning units are provided in the cleaning device, mounted at different positions on the cleaning device, and/or if a number of cleaning units of different types are provided on the cleaning device, a control signal in which it is specified which of the cleaning units is to be activated or switched off may be
5 transmitted to the receiver by the EUV lithography system.

In addition or as an alternative, the cleaning device may also have a receiver, in particular a radio receiver, which transmits measurement data recorded by the cleaning device to the EUV lithography system. The measurement data may be
10 determined with the aid of a measuring device and/or with the aid of sensors, which are described more specifically further below. It goes without saying that the receiver and the transmitter may be integrated in a common structural unit.

In a further embodiment, the cleaning device additionally comprises at least one
15 measuring device for producing a spatially resolved image of the environment of the cleaning device. In the simplest case, the measuring device may be a (miniaturized) camera, which projects an image of at least a partial region of the environment of the cleaning device. With the aid of the measuring device, on the one hand particles on surfaces located in the environment can be detected
20 and on the other hand the EUV lithography system itself can be inspected, for example in that the condition of components located in the EUV lithography system, for example vacuum pumps or the like, can be investigated with the aid of the measuring device. For this purpose, while it is being transported by means of the transporting device, the cleaning device may be brought to
25 monitoring positions within the EUV lithography system provided especially for the inspection of such components.

In one embodiment, the cleaning device additionally comprises a measuring device for the detection of particles that are in the gas phase in the EUV
30 lithography system and/or for the detection of gas flows in the EUV lithography system. The measuring device may in particular be formed in the way described

further above and produce a spatially resolved image of the environment of the cleaning device. Light scattered at the particles, which may for example be generated by a light source that is integrated in the cleaning device or provided at some other location and illuminates a region to be investigated, may be used for example for the detection of the particles. On the basis of a comparison of a number of images recorded at successive times by the measuring device, a direction of flow of the particles in the EUV lithography system can be determined, i.e. a flow analysis of the particles can be performed.

It is also possible as an alternative or in addition to a flow analysis of particles to measure a gas flow or the direction of flow and the strength of the flow of gases that are present in the EUV lithography system, the molecular sizes of which are typically much smaller than customary particle sizes. The measuring device that produces a spatially resolved image of the environment of the cleaning device may possibly likewise be used for this purpose, but it is also possible to provide in the cleaning device a measuring device that carries out a pressure measurement of the ambient pressure. While the cleaning device is being transported through the EUV lithography system, the ambient pressure in the vacuum environment can in this way be measured along the path of movement of the cleaning device, and consequently in a location-dependent manner, and in this way a location-dependent pressure profile or pressure gradient can be created along the path of movement of the cleaning device. On the basis of this pressure profile, the direction of flow and the strength of gas flows in the EUV lithography system can be determined. Such a measuring device may possibly also have two or more pressure sensors, which are mounted at two or more different locations on the cleaning device, in order to measure a pressure gradient, and thereby the direction and strength of a gas flow, that is present at a predetermined location, for example at the exposure position, in the vacuum environment of the cleaning device.

In a further embodiment, the cleaning device additionally comprises at least one position and/or acceleration sensor for sensing the position and/or the acceleration of the cleaning device. Such a sensor is advantageous in order that the cleaning device can autonomously detect the reaching of certain positions, for example the exposure position, within the EUV lithography system. The cleaning device may for example have a memory, stored in which are certain positions in the EUV lithography system, which are compared with the current position of the cleaning device in the EUV lithography system. It can in particular be established by the acceleration sensor whether the cleaning device is being moved in the EUV lithography system or is at a standstill, i.e. has reached a defined position when transporting the cleaning device within the EUV lithography system. The acceleration sensor and the position sensor may be used for activating the cleaning unit of the cleaning device as soon as the reaching of a predetermined position and/or a standstill of the cleaning device is/are detected. In this way it may be possible to dispense with an activation of the cleaning device by a control signal sent by the EUV lithography system, and consequently possible to dispense altogether with a receiver for receiving control signals.

In a further embodiment, the cleaning device additionally comprises at least one temperature sensor for sensing a temperature in the environment of the cleaning device. The sensing of the temperature in the environment of the cleaning device is advantageous in particular whenever the cleaning unit of the cleaning device has a cooling and/or heating device, since in this case the temperature produced by the cooling and/or heating device can be monitored and possibly controlled to a desired temperature value.

A further aspect of the invention relates to an EUV lithography system, which has a cleaning device as described above and also a transporting device for selectively transporting an exposure mask or the cleaning device to a mask holder of the EUV lithography system arranged at an exposure position or for

selectively transporting a wafer or the cleaning device to a wafer holder of the EUV lithography system arranged at an exposure position. As described further above, the cleaning device has dimensions which coincide with the dimensions of an exposure mask or a wafer of the EUV lithography system, so that the
5 transporting of the cleaning device can take place by means of the same transporting device as the transporting of the exposure mask or the transporting of the wafer.

In particular, the cleaning device may be stored or placed in a magazine of the
10 EUV lithography system in which exposure masks or wafers of the EUV lithography system are also stored. In the same way as the exposure masks or the wafers, the cleaning device may be brought out of the magazine to a removal position, at which a vacuum lock is provided. In this way, the cleaning device can be removed from the EUV lithography system without the vacuum in
15 the EUV lithography system having to be broken for this purpose.

As described further above, for the purposes of this application an EUV lithography system is also understood as meaning a device for the inspection of exposure masks or wafers for EUV lithography, in this case the exposure
20 position described above corresponding to a measuring position at which the exposure mask or the wafer is positioned for the purpose of inspection or measurement. In the case of an EUV lithography apparatus, the exposure position of the mask is typically the object field and the exposure position of the wafer is typically the image field of a projection lens or a projection optical unit.

25 In one embodiment, the EUV lithography system has at least one purging device for feeding a purging gas in the direction of the cleaning device arranged at a cleaning position in the EUV lithography system. The purging gas, which is emitted from the purging device, to be more precise from a gas outlet of the
30 purging device, is preferably guided along at least one surface on which particles have been deposited or may have been deposited, in order to intensify

the action of the cleaning device and assist the removal of particles from the surface. The total pressure of the purging gas when cleaning the surface may vary over a great pressure range of for example about 10^{-4} Pa to 1 Pa; the gas flow of the purging gas stream used for the cleaning may also be varied.

5

In addition or as an alternative to a purging device that has a local gas outlet for the directed guidance of the purging gas to the cleaning device arranged at the cleaning position, a purging device that flushes the entire vacuum environment with a purging gas but does not produce a purging gas stream directed onto the
10 cleaning device may be used to assist the cleaning action of the cleaning device.

15

In addition or as an alternative to a purging device, an irradiating device may also be provided in the EUV lithography system, in order to radiate
electromagnetic radiation, for example at wavelengths in the EUV range or at
other wavelengths, directly or indirectly onto the mask or onto contaminated
surfaces, in order in this way to assist the removal of contaminants.

20

The invention also relates to a method for cleaning an EUV lithography system,
in particular for cleaning a mask holder for mounting an exposure mask or a
wafer holder for mounting a wafer of the EUV lithography system, comprising:
transporting a cleaning device as described above to a cleaning position in the
EUV lithography system, in particular to an exposure position, at which the
mask holder or the wafer holder is arranged, and activating at least one
25 cleaning unit of the cleaning device for acting, in particular contactlessly, on
particles in the environment of the cleaning device. If the cleaning position
coincides with the exposure position, the fixedly arranged mask holder or the
fixedly arranged wafer holder is cleaned by means of the cleaning device.

25

30

However, it is also possible to arrange the cleaning device at other cleaning
positions within the EUV lithography system, in order to remove particles that
are present there, for example at transfer positions at which the exposure mask

or the wafer is transferred between different mechanically movable components, for example in the form of (robot) arms, of the transporting device. In this case, a mounting element in which the cleaning device is held while it is being transported by means of the transporting device and which may for example take the form of a frame, may be cleaned by means of the cleaning device. Such a mounting element may possibly also be cleaned while the cleaning device is being moved through the EUV lithography system with the aid of the mounting element or with the aid of the transporting device, i.e. it is possibly not necessary to interrupt the transport of the cleaning device for the cleaning of such a mounting element.

Further features and advantages of the invention emerge from the following description of exemplary embodiments of the invention, on the basis of the figures in the drawing, which show details essential to the invention, and from the claims. The individual features can be realized respectively on their own or together in any combination in one variant of the invention.

Drawing

Exemplary embodiments are represented in the schematic drawing and are explained in the subsequent description. In detail:

Fig. 1 shows a schematic representation of an EUV lithography apparatus with an exposure mask, a mask holder, a wafer and also a wafer holder,

Fig. 2a shows a schematic representation of a cleaning device, which has the geometry of the exposure mask from Fig. 1,

Fig. 2b shows a schematic representation of a cleaning device, which has the geometry of the wafer from Fig. 1,

- Fig. 3a,b show schematic representations of cleaning devices with the geometry of the exposure mask from Fig. 1, which respectively have a cleaning unit with a field generating device for generating an inhomogeneous electrostatic field,
- Fig. 4 shows a schematic representation of the mask holder from Fig. 1 for holding the exposure mask at an exposure position,
- Fig. 5 shows a schematic representation of a mounting element for placing a mask or the cleaning device while it is being transported by means of a transporting device, and also
- Fig. 6 shows a sectional representation of the mask holder from Fig. 3.

In the following description of the drawings, identical reference signs are used for identical or functionally identical components.

Fig. 1 shows an EUV lithography system in the form of an EUV lithography apparatus 101 in a highly schematic way. The EUV lithography apparatus 101 has an EUV light source 102 for generating EUV radiation, which has a high energy density in an EUV wavelength range below 50 nm, in particular between about 5 nm and about 15 nm. The EUV light source 102 may for example take the form of a plasma light source for generating a laser-induced plasma or be formed as a synchrotron radiation source. In particular in the former case, a collector mirror 103 may be used, as shown in Fig. 4, in order to focus the EUV radiation of the EUV light source 102 into an illumination beam 104 and in this way increase the energy density further. The illumination beam 104 serves for the illumination of a structured object in the form of an exposure mask M by means of an illumination system 110, which in the present example has five reflective optical elements 112 to 116 (mirrors).

The structured object is a reflective exposure mask M, which has reflective and nonreflective, or at least much less reflective, regions for producing at least one structure on the reflective exposure mask M. The exposure mask M reflects part of the illumination beam 104 and forms a projection beam path 105, which carries the information about the structure of the exposure mask M and is irradiated into a projection lens 120, which produces an image of the exposure mask M or of a respective partial region thereof on a substrate W. The substrate W, for example a wafer, comprises a semiconductor material, for example silicon, and is arranged on a mounting, which is also referred to as a wafer stage WS.

In the present example, the projection lens 120 has six reflective optical elements 121 to 126 (mirrors), in order to produce an image of the structure that is present on the exposure mask M on the wafer W. The number of mirrors in a projection lens 120 typically lies between four and eight; however, only two mirrors may also possibly be used.

In the imaging or the exposure of the wafer W, a mask stage (reticle stage) RS, at which the exposure mask M is held on a mask holder RH, and also the wafer stage WS are moved along a scanning direction X. In order to achieve a high imaging quality in the imaging of a respective object point OP of the exposure mask M onto a respective image point IP on the wafer W, highest requirements are to be imposed on the surface form of the mirrors 121 to 126; and the position or the alignment of the mirrors 121 to 126 in relation to one another and in relation to the exposure mask M and the substrate W also requires precision in the nanometer range.

The exposure mask M may be brought from an exposure position EX, in which the exposure mask M is arranged in the illumination beam 104, to a transfer position HP and back by means of a transporting device 20, which in the

example shown has a pivotable (robot) arm 21. For this purpose, the exposure mask M, which is securely held mechanically or in some other way, for example by electrostatic attraction or by negative pressure, on a mask holder RH arranged at the exposure position EX, is released from the mask holder RH and, by pivoting of the arm 21, is brought into the transfer position HP, in which the exposure mask M can for example be transferred to a further pivotable (robot) arm (not shown), which brings the exposure mask M for example into a magazine formed in the EUV lithography apparatus 101 for the placement of exposure masks M.

The wafer W may be brought from an exposure position EX, in which the wafer W is arranged in the illumination beam 104 at an image field, to a transfer position HP and back by means of a further transporting device 30 for the wafer W, which is formed in a way analogous to the transporting device 20 for the mask M, and which in the example shown has a pivotable (robot) arm 31. For this purpose, the wafer W, which is securely held mechanically or in some other way, for example by electrostatic attraction or by negative pressure, on a wafer holder WH arranged at the exposure position EX, is released from the wafer holder WH and, by pivoting of the arm 31, is brought into the transfer position HP, in which the wafer W can be transferred to a further pivotable (robot) arm or the like, which brings the wafer W for example into a magazine formed in the EUV lithography apparatus 101 for the placement of wafers W.

The transporting devices 20, 30 may also bring the exposure mask M or the wafer W to further positions in the EUV lithography apparatus 101, for example to a removing or feeding position (not shown), at which the exposure mask M or the wafer W can be removed from the EUV lithography apparatus 101 at a vacuum lock. It goes without saying that, in place of the pivotable arm 21, 31, the transporting device 20, 30 for transporting the exposure mask M or the wafer W may also have other or additional movable devices, for example tiltable / pivotable robot arms, etc.

Fig. 2a shows a cleaning device 1, which has a rectangular geometry and a small thickness D, of typically about 6.35 mm. The cleaning device 1 has the same dimensions as the exposure mask M, for example a length of 152 mm and a width of 152 mm, and can therefore be transported through the EUV lithography apparatus 101 by means of the transporting device 20 shown in Fig. 1, and in particular be brought to the mask holder RH of the mask stage RS and be held by the mask holder RH. The cleaning device 1 is consequently transported by the transporting device 20 like a customary exposure mask M, so that the cleaning device 1 may also be referred to as a cleaning mask.

Fig. 2b shows a cleaning device 1', which has a circular geometry and a small thickness D, of typically about 0.3 mm. The cleaning device 1' has the same dimensions as a wafer W, for example a diameter d of 300 mm, and can therefore be transported through the EUV lithography apparatus 101 by means of the further transporting device 30 shown in Fig. 1, and in particular be brought to the wafer holder WH of the wafer stage WS and be held by the wafer holder WH. The cleaning device 1' is consequently transported by the further transporting device 30 like a customary wafer W, so that the cleaning device 1' can also be referred to as a cleaning wafer.

The cleaning devices 1, 1' shown in Figs. 2a,b have a flat main body 2, integrated in which there is a providing device 3 for providing electrical energy in the form of an electrical battery or the like. In the example shown, the cleaning device 1, 1' has a number of cleaning units 4, 5, 6a,b, 7a,b, which are formed in different ways and the functioning of which is described more specifically further below.

First, however, a further example of a mask holder RH and a further mounting element 22, which serve for the mounting or placing of the mask M or the cleaning device 1 from Fig. 2a, are described on the basis of **Fig. 4** to **Fig. 6**. A

more detailed representation of the wafer holder WH for the cleaning device 1' from Fig. 2b has not been shown, because no peculiarities arise in this respect apart from the circular geometry.

5 At the mask holder RH shown in plan view in Fig. 4, the mask M is engaged from underneath by means of a mounting element 23 in the form of a frame, to be more precise a U-shaped mounting element, with the aid of three contact elements 24a-c formed as abrasion-resistant pins, of which a first contact element 24a is formed in the middle of the middle leg of the U-shaped mounting
10 element 23 and a second and third contact element 24b,c are formed at the free ends of the two outer legs 25a,b of the U-shaped mounting element 23. If the cleaning device 1 is placed by means of the transporting device 20 in the mask holder RH, the cleaning device 1 rests on the three contact elements 24a-c, as can also be seen in the sectional representation of the mask holder RH shown
15 in Fig. 6.

As can likewise be seen in Fig. 6, the cleaning device 1 (and correspondingly the exposure mask M) are protected from contaminants in the mask holder RH by a cover 26. The cleaning device 1 is freely accessible at its longitudinal
20 edges, i.e. a gap is formed between the cleaning device 1 and the cover 26. This makes it possible to place and hold the cleaning device 1, and correspondingly the exposure mask M, by means of a further mounting element 22, shown in Fig. 5, which is mounted on the pivotable arm 21 of the transporting device 20 that is shown in Fig. 1. The further mounting element 22
25 is formed in a way similar to the mask holder RH shown in Fig. 4, i.e. it is likewise formed in a substantially U-shaped manner, and has three contact elements 24a-c for mounting the cleaning device 1 or the exposure mask M.

Abrasion at the contact elements 24a-c both of the mask holder RH and of the
30 further mounting element 22 of the transporting device 20 cannot be avoided completely, i.e. there is the formation and deposition of particles P in the region

of the contact elements 24a-c (cf. Fig. 6). In the example shown, each of the cleaning units 4, 5, 6a,b, 7a,b is mounted on one of the two longitudinal sides of the rectangular main body 2, so that, irrespective of the orientation of the rectangular cleaning device 1 when it is placed in the mask holder RH or in the further mounting element 22, one of the cleaning units 4, 5, 6a,b, 7a,b is respectively arranged in the region of one of the contact elements 24a-c. It goes without saying that the upper side of the cleaning device 1 as shown in Fig. 2a,b should be arranged with the cleaning units 4, 5, 6a,b, 7a,b facing the particles P. A suitable orientation of the cleaning device 1 or of the exposure mask M is in any case performed however by the transporting device 20 (and also by the further transporting device 30 for transporting the wafer W).

The cleaning units 4, 5, 6a,b, 7a,b can act on the particles P deposited in the environment of the cleaning device 1 in order to remove them from the mask holder RH or from the further mounting element 22. The action on the particles P by means of the cleaning units 4, 5, 6a,b, 7a,b advantageously takes place contactlessly, as described more specifically further below. It goes without saying that the cleaning units 4, 5, 6a,b, 7a,b of the cleaning device 1' shown in Fig. 2b can act in an analogous way on particles P deposited in the environment of the cleaning device 1' in order to remove them from the wafer holder WH or from a further mounting element on which the wafer W can be mounted.

A first cleaning unit 4 of the cleaning device 1 has a field generating device 4a for generating an electrostatic field E in order to attract dielectric particles P, for example in the form of dust, electrostatically and thereby bind them to the surface of the first cleaning unit 4. The surface of the first cleaning unit 4 may have structures that can be electrostatically charged to generate the electrostatic field. The electrically chargeable structures, which may for example comprise electrical lines, may be applied to the main body 2 of the cleaning device 1, for example with the aid of a lithographic process.

A second cleaning unit 5 of the cleaning device 1 has an actuating element 8 for generating vibrations, which in the example shown is formed as an ultrasound transmitter for generating ultrasound waves, in order to remove the particles P from the surface of the U-shaped mounting element 23 or from the further
5 mounting element 22, which is arranged adjacent to the cleaning device 1 (cf. Fig. 6).

Two third cleaning units 6a,b of the cleaning device 1 respectively have a cooling device 9, which in the example shown take the form of Peltier elements.
10 The cooling devices 9 produce a temperature gradient between the cleaning device 1 and the mask holder RH or the surface of the respective mounting element 23, 22 in the form of a frame on which the particles P are formed. The temperature gradient may cause a thermophoresis, in which the particles P are transported from the warmer surface of the respective mounting element 23, 22
15 to the colder surface of the cooling device 9. It may also be possible to provide in addition or as an alternative to the cooling device 9 a heating device in a respective third cleaning unit 6a,b or to provide a combined cooling and heating device in a respective third cleaning unit 6a,b.

20 Two fourth cleaning units 7a,b of the cleaning device 1 respectively have a nozzle 10 for the discharging of a cleaning gas 11, for example in the form of nitrogen or compressed air. As can be seen in Fig. 2a,b, the two fourth cleaning units 7a,b are arranged approximately in the middle of the respective longitudinal sides of the cleaning device 1, so that, when they are mounted in
25 the mask holder RH or in the further holding device 22, one of the two cleaning units 7a,b is arranged in the direct vicinity of the first contact point 24a, which is provided in the middle of the middle leg of the U-shaped mounting element 23. In this region, a connection can be established between the gas nozzle 10 and a supply line (not shown), allowing the cleaning gas 11 to be conducted into a
30 feed line to the gas nozzle 10 that is provided in the fourth cleaning unit 7a,b. The gastight connection to the supply line provided at the mask holder RH can

be established with the aid of the providing device 3, which acts on a mechanical component (not shown), for example on an adapter or the like, in order to establish the connection to a gas connection provided in the fourth cleaning unit 7a,b. It is alternatively possible that the gastight connection is established by a component provided in the EUV lithography apparatus 101, for example an adapter or the like. A corresponding connecting line may also be provided at the further mounting element 22.

As an alternative to feeding the cleaning gas 11 to the fourth cleaning units 7a, 7b by means of a supply line, the cleaning gas 11 itself may possibly be kept in a reservoir in a liquefied form in the respective fourth cleaning units 7a,b. As and when required, the cleaning gas 11 can in this case be removed from the reservoir and discharged through the nozzle 10 in the direction of the particles P.

The cleaning device 1, 1' may also have further, not graphically represented cleaning units, which are designed for acting contactlessly on the particles P on the contact elements 24a-c. For example, the flat or plate-shaped main body 2 may have a cleaning unit in the form of a cleaning surface or layer, in particular a sticky surface or layer, in order to transfer the particles P from the contact elements 24a-c to the cleaning device 1, 1'. For this purpose, the surface of the main body 2 of the cleaning device 1, 1' or a partial region of the surface of the main body 2 may be provided with a coating of adhesive material, for example a carbon coating, a polyurethane elastomer or a self-adhesive Kapton® tape. The probability of a particle P, for example in the form of a flake, being deposited on the sticky layer of the cleaning unit is greater than the probability of it being deposited on a mask used for the exposure or a wafer used for the exposure.

As can likewise be seen in Fig. 2a, the cleaning device 1 has in the region of the providing device 3 a receiver 12 and also a transmitter 13, which may be integrated in a common structural unit. The receiver 12 serves for receiving

control signals 14, which are transmitted from the EUV lithography apparatus 101 to the cleaning device 1. The control signals 14 may comprise in particular control commands for activating or deactivating one or more of the cleaning units 4, 5, 6a,b, 7a,b. The cleaning device 1' shown in Fig. 2b is formed in an analogous way, i.e. it likewise has in addition to the cleaning units 4, 5, 6a,b, 7a,b a receiver 12 and a transmitter 13.

It is typically undesired that the cleaning device 1, 1' carries out cleaning all the time it is being transported by means of the transporting device 20 in the EUV lithography apparatus 101. The cleaning device 1, 1' should generally only be activated at certain positions, so-called cleaning positions, within the EUV lithography apparatus 101, for example when it has been placed at the exposure position EX in the mask holder RH or in the wafer holder WH or when it is arranged at other suitable cleaning positions, for example at the transfer position HP shown in Fig. 1.

Since the EUV lithography apparatus 101, to be more precise a control unit provided in it, knows the position of the pivotable arm 21, 31 or generally the position of the exposure mask M or the wafer W, and consequently also of the cleaning device 1, 1' while it is being transported by means of the transporting device 20, 30, the EUV lithography apparatus 101 can activate one or more of the cleaning units 4, 5, 6a,b, 7a,b to act on particles P in the environment of the cleaning device 1, 1' when it reaches a respective position intended for cleaning.

For this purpose, a control signal 14, which contains the command for activating and possibly deactivating a respective cleaning unit 4, 5, 6a,b, 7a,b, may be transmitted to the receiver 12. Alternatively, after activation, the cleaning unit 4, 5, 6a,b, 7a,b may remain activated for a predetermined time period that is stored in the cleaning device 1, 1' and be deactivated automatically after this time period has elapsed. The activation of the cleaning units 4, 5, 6a,b, 7a,b is

respectively performed with the aid of the providing device 3, which makes available the electrical energy required for the operation of the cleaning units 4, 5, 6a,b, 7a,b.

5 **Fig. 3a,b** respectively show a cleaning device 1 with a main body 2, which, like the cleaning device 1 from Fig. 2a, has the rectangular, flat geometry of the exposure mask from Fig. 1. In Fig. 3a,b, the cleaning device 1 is mounted at the exposure position EX (cf. Fig. 1) on a mask holder RH, which, unlike the mask holder RH shown in conjunction with Fig. 4 to Fig. 6, holds the cleaning device 1
10 on a flat side or planar surface 2b of the main body 2 that is facing the mask holder RH with the aid of an electrostatic force. The mask holder RH from Fig. 3a,b is mounted on the mask stage RS shown in Fig. 1.

The cleaning device 1 shown in Fig. 3a,b has a field generating device 4 for
15 generating the electrostatic field E, which in the case of the example shown in Fig. 3a has precisely one electrode 4a. The electrode 4a is formed in the manner of a burl with an approximately hemispherical geometry and projects beyond the planar surface 2a of the main body 2 of the cleaning device 1 that is facing away from the mask holder RH.

20 The electrode 4a is electrically insulated from the rest of the surface 2a of the main body 2, which in the example shown is achieved by the remaining surface 2a being formed from an electrically insulating material. The electrode 4a, which projects beyond the planar surface 2a, generates an inhomogeneous
25 electrostatic field E, the field strength of which decreases from the electrode 4a, as can be seen in Figure 3a from the distance between the field lines, represented as dashed lines, increasing from the electrode 4a, the field lines ending at an electrically conducting vacuum component 40 of aluminium, which is arranged lying opposite the mask holder RH in the EUV lithography
30 apparatus 101.

The inhomogeneous electrostatic field E that is generated by the electrode 4a induces in a particle P represented on the left side in Fig. 3a a dipole moment p , which leads to the particle P being subjected to a force F that is directed in the direction of the higher field strength of the inhomogeneous electrostatic field E , i.e. in the example shown in the direction of the electrode 4a. The particle P therefore moves in the inhomogeneous electrostatic field E towards the electrode 4a and may be deposited on it or on the cleaning device 1.

Likewise shown in Fig. 3a is a purging device 19, which serves for producing an inert purging gas 19a or a purging gas flow, which feeds the purging gas 19a to the cleaning device 1. The purging gas 19a is an inert gas, which is guided from the purging device 19 along the surface of the vacuum component 40, which is arranged lying opposite the cleaning device 1. The purging gas 19a or the purging gas stream takes with it flake-like particles P from the contaminated surface 40a of the vacuum component 40 and transports them into the vicinity of the cleaning device 1, to be more precise in the direction of the electrode 4a or into the region of the inhomogeneous electrostatic field E , in which the particles P are moved in the direction of the electrode 4a.

As an alternative or in addition to the purging device 19 shown in Fig. 3a, to assist the cleaning, the contaminated surface 40a may also be irradiated with electromagnetic radiation, which has wavelengths in the EUV range or possibly in another wavelength range, for example in the UV wavelength range. The cleaning device 1, to be more precise its first flat side 2a, may possibly also be irradiated with EUV radiation, in that the EUV light source 102 is activated with lower power than is the case during the exposure, in order in this way to assist the cleaning process.

In the case of the example shown in Fig. 3a, the cleaning device 1 has a providing device 3 for providing electrical energy, which serves as an interface in the form of an electrical through-connection between the electrode 4a of the

cleaning unit 4, which is arranged on the first flat side 2a of the main body 2, facing away from the mask holder RH, and the second flat side 2b, alongside the mask holder RH. The providing device 3 or the through-connection has on the second flat side 2b of the main body 2 a contact area, which is in contact
5 with an electrically conductive contact element 24, for example a burl-like element, of the mask holder RH. The contact element 24 is in connection with a not graphically represented energy source, for example with a voltage source, in order to generate at the electrode 4a an electrical potential greater than the environment.

10 The cleaning device 1 shown in Fig. 3b differs from the cleaning device 1 shown in Fig. 3a in that the providing device 3 takes the form of a battery or the like, for example the form of a capacitor. The battery does not have an interface with the environment and is typically exchangeable, so that it can be exchanged before
15 the cleaning device 1 is introduced into the EUV lithography apparatus 101, so that it is ensured that there is always a charged battery 3 in the cleaning device 1. In the EUV lithography apparatus 101 itself there may possibly be arranged a charging station for charging the battery serving as a providing device 3, in the latter case the providing device 3 having an interface for connection to the
20 charging station.

The cleaning device 1 shown in Fig. 3b also differs from the cleaning device 1 shown in Fig. 3a in that it has two electrodes 4a, 4b, which are kept by the providing device 3 at the same electrical potential, which is typically greater
25 than the electrical potential in the environment of the cleaning device 1 or than the electrical potential of the vacuum component 40. As in Fig. 3a, in Fig. 3b too the electrostatic field E generated by the two electrodes 4a, 4b is inhomogeneous and has the maximum field strength in the region of the electrodes 4a, 4b. To produce the greatest possible inhomogeneity of the field
30 strength of the electrostatic field E, in the case of the example shown in Fig. 3b the electrodes 4a, 4b substantially take the form of needles.

The cleaning device 1, 1' shown in Fig. 2a,b additionally has a measuring device 16 for observing the environment of the cleaning device 1, 1'. In the example shown, the measuring device 16 is a camera, which produces a spatially resolved image of the environment of the cleaning device 1, 1'. The measuring device 16 may serve the purpose of investigating surfaces in the vicinity of the cleaning device 1 for particles P deposited there, in order to decide whether cleaning of the surfaces is required.

The measuring device 16 may also be used for observing and possibly diagnosing faults in other components provided in the EUV lithography apparatus 101. For this purpose, the cleaning device 1, 1' may be arranged, possibly with the aid of the transporting device 20, 30, at monitoring positions especially provided for this purpose in the EUV lithography apparatus 101. At such a monitoring position, for example the state of contamination of vacuum pumps or the like that are present in the EUV lithography apparatus 101 can be monitored.

The measuring device 16 may also serve the purpose of detecting particles P that are in the gas phase (cf. Fig. 1) in the EUV lithography apparatus 101 and for determining in this way the degree of contamination of the EUV lithography apparatus 101 in the gas phase. The particles P that are in the gas phase can be detected on the basis of scattered light that occurs when they are illuminated by means of a light source, for example by means of a laser or a laser diode. The light source may likewise be integrated in the cleaning device 1 or possibly arranged at some other location within the EUV lithography apparatus 101. The evaluation of a number of successively taken images of the particles P that are in the gas phase allows conclusions to be drawn about the flow behaviour of the particles P in the EUV lithography apparatus 101.

The measuring device 16 may also serve the purpose of detecting on the basis of the spatially resolved image of the environment of the cleaning device 1, 1' a gas flow G (cf. Fig. 1) of a residual gas present in the EUV lithography apparatus 101. Such a residual gas differs from the particles P by the typically much smaller molecular size (for example in the case of hydrogen as the residual gas). For the detection of a gas flow, the measuring device 16 may possibly have as an alternative or in addition to a camera one or more pressure sensors, in order to measure a pressure in the vacuum environment of the cleaning device 1, 1'. During the movement of the cleaning device 1, 1' by means of the transporting device 20, 30 through the EUV lithography apparatus 101, a locationally dependent pressure profile can in this way be created along the path of movement, and on this basis the direction of a gas flow G (from a region with a higher (ambient) pressure to a region with a lower (ambient) pressure in the EUV lithography apparatus 101) can be concluded, and the strength of the gas flow G can be concluded from the measured difference in pressure. The cleaning device 1, 1' may possibly have a measuring device 16, which has two or more pressure sensors, which are arranged distributed at a number of locations of the cleaning device 1, 1', in order to be able to detect a pressure gradient and on this basis the strength and direction of a gas flow G even in the case where the cleaning device 1, 1' is not being moved, for example when it is arranged at the exposure position EX.

In the example shown, integrated in the cleaning device 1 there is also a combined position and acceleration sensor 17, which is designed for determining the position and the acceleration of the cleaning device 1, 1' while it is being transported within the EUV lithography apparatus 101. On the basis of the position determined by means of the sensor 17, the reaching of a predetermined cleaning position, which may for example be the exposure position EX or the transfer position HP, can be determined. The acceleration sensor 17 may also serve the purpose of checking whether the cleaning device 1 is at rest, i.e. at that moment is not being moved through the EUV lithography

apparatus, before one or more of the cleaning units 4, 5, 6a,b, 7a,b is/are activated.

In the case of the example shown in Fig. 2a,b, additionally integrated in the cleaning device 1, 1' is a temperature sensor 18, which serves for measuring the temperature T in the environment of the cleaning device 1, 1'. The measurement of the temperature T is advantageous in particular whenever the third cleaning units 6a,b, having the cooling and/or heating device 9, are activated in order to be able to control the temperature produced by the cooling and/or heating device 9 in the environment of the cleaning device 1 on the basis of the measured actual temperature T to a setpoint temperature.

Both the measurement data 15 supplied by the sensors 17, 18 and the measurement data 15 supplied by the measuring device 16 can be transmitted with the aid of the transmitter 13 to the EUV lithography apparatus 101 or possibly to an evaluation device provided outside the EUV lithography apparatus 101, for example to a computer. Unlike the situation shown in Fig. 2a,b, the cleaning device 1, 1' may also operate fully autonomously, i.e. not have a receiver 12, but perform the activation of one or more of the cleaning units 4, 5, 6a,b, 7a,b and also possibly the measuring device 16 on the basis of the sensor signals supplied by the position and acceleration sensor 17.

Patent Claims

1. Cleaning device (1, 1') with a geometry adapted for mounting on a mask holder (RH) of an exposure mask (M) or for mounting on a wafer holder (WH) of a wafer (W) of an EUV lithography system (101), comprising:
a providing device (3) for providing electrical energy, and also
at least one cleaning unit (4, 5, 6a,b, 7a,b) for acting, in particular contactlessly, on particles (P) in the environment of the cleaning device (1, 1'), the cleaning unit (4, 5, 6a,b, 7a,b) being in connection with the providing device (3) for the drawing of electrical energy.
2. Cleaning device according to Claim 1, in which the cleaning unit (4) has at least one field generating device (4a, 4b) for generating an electrostatic field (E).
3. Cleaning device according to Claim 2, in which the field generating device for generating the electrostatic field (E) has at least one electrode (4a), preferably at least two electrodes (4a, 4b).
4. Cleaning device according to Claim 2 or 3, in which the field generating device (4a; 4a, 4b) is designed for generating an inhomogeneous electrostatic field (E).
5. Cleaning device according to Claim 3 or 4, in which at least one electrode (4a; 4a, 4b) projects beyond a planar surface (2a) of the cleaning device (1).
6. Cleaning device according to one of the preceding claims, in which the cleaning unit (5) has at least one actuator (8) for generating vibrations.

7. Cleaning device according to one of the preceding claims, in which the cleaning unit (6a,b) has at least one cooling and/or heating device (9).
8. Cleaning device according to one of the preceding claims, in which the cleaning unit (7a,b) has at least one nozzle (10) for the discharging of a cleaning gas (11).
9. Cleaning device according to one of the preceding claims, further comprising: a receiver (12) for receiving control signals (14) of the EUV lithography system (101) and/or a transmitter (13) for transmitting measurement data (14) of the cleaning device (1, 1') to the EUV lithography system (101).
10. Cleaning device according to one of the preceding claims, further comprising: at least one measuring device (16) for producing a spatially resolved image of the environment of the cleaning device (1, 1').
11. Cleaning device according to one of the preceding claims, further comprising: at least one measuring device (16), which is designed for detecting particles (P) that are in the gas phase in the EUV lithography system (101) and/or for detecting gas flows (G) in the EUV lithography system (101).
12. Cleaning device according to one of the preceding claims, further comprising: at least one position and/or acceleration sensor (17) for sensing the position and/or the acceleration of the cleaning device (1, 1').
13. Cleaning device according to one of the preceding claims, further comprising: at least one temperature sensor (18) for sensing a temperature (T) in the environment of the cleaning device (1, 1').

14. EUV lithography system (101), comprising:

a cleaning device (1, 1') according to one of the preceding claims, and also a transporting device (20, 30) for selectively transporting an exposure mask (M) or the cleaning device (1) to a mask holder (RH) of the EUV lithography system (101) arranged at an exposure position (EX) or for selectively transporting a wafer (W) or the cleaning device (1') to a wafer holder (WH) of the EUV lithography system (101) arranged at an exposure position (EX).

15. EUV lithography system according to Claim 14, further comprising:

at least one purging device (19) for feeding in a purging gas (19a) in the direction of the cleaning device (1, 1') arranged at a cleaning position (EX, HP) in the EUV lithography system (101).

16. Method for cleaning an EUV lithography system (101), in particular for

cleaning a mask holder (RH) for mounting an exposure mask (M) or a wafer holder (WH) for mounting a wafer (W) of the EUV lithography system (101), comprising:

transporting a cleaning device (1, 1') according to one of Claims 1 to 14 to a cleaning position (EX, HP) in the EUV lithography system (101), in particular to an exposure position (EX), at which the mask holder (RH) or the wafer holder (WH) is arranged, and also

activating the at least one cleaning unit (4, 5, 6a,b, 7a,b) for acting, in particular contactlessly, on particles (P) in the environment of the cleaning device (1, 1').

1 / 3

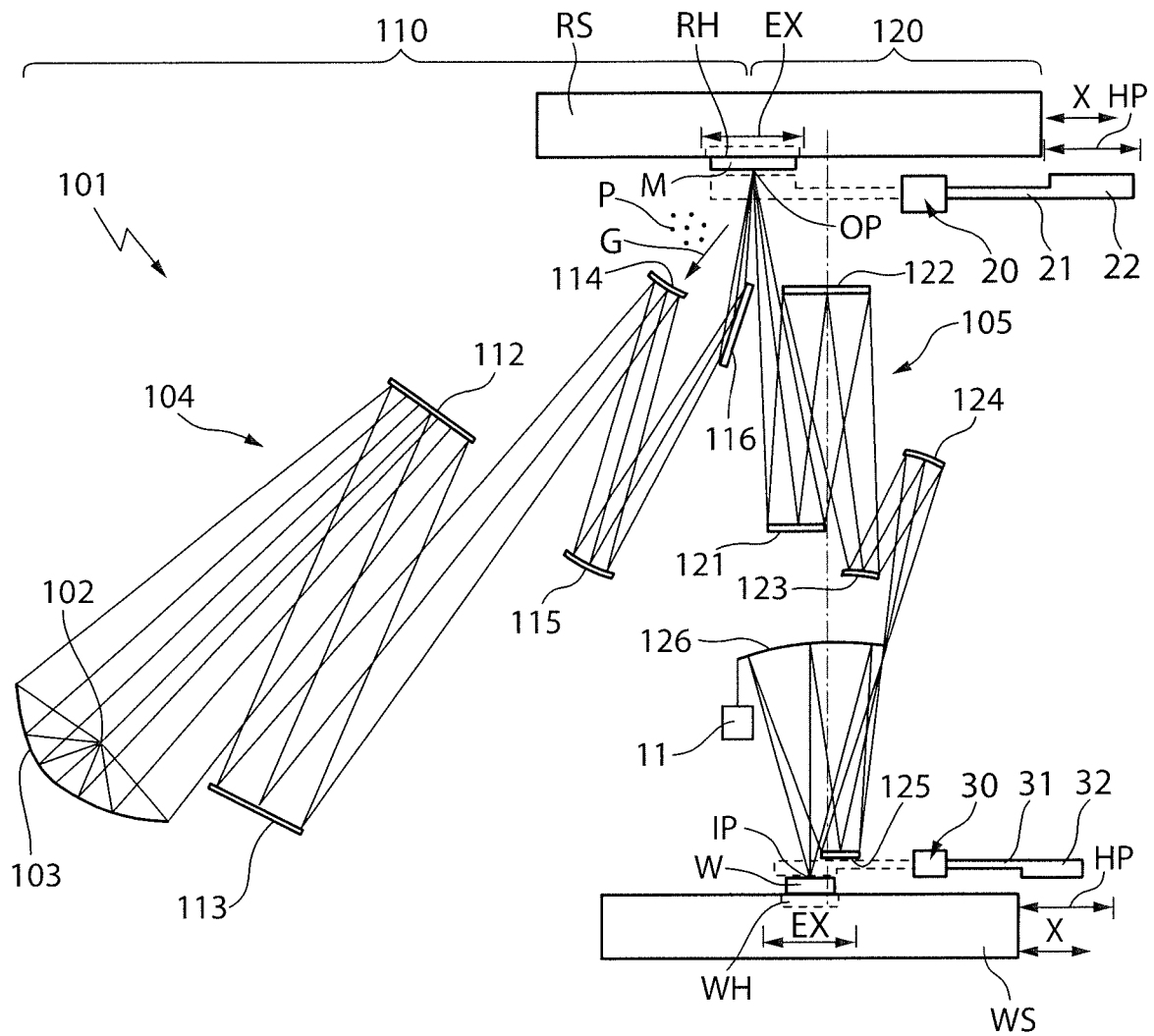


Fig.1

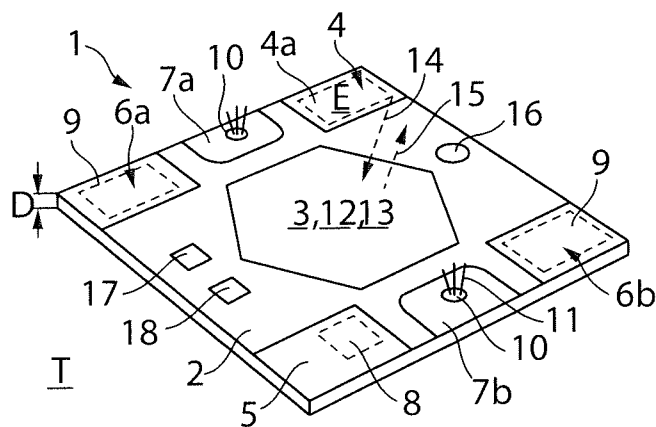


Fig. 2a

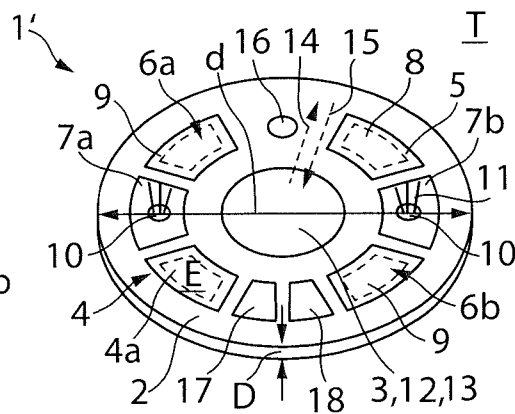


Fig. 2b

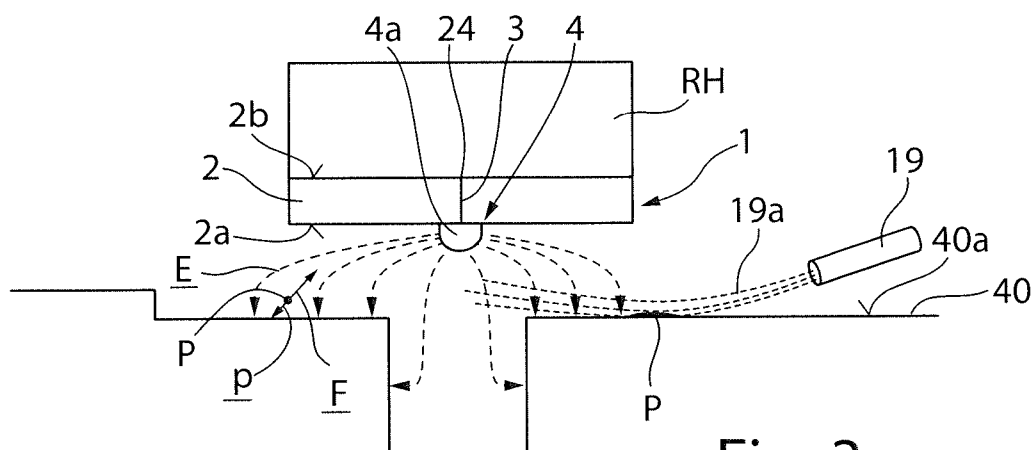


Fig. 3a

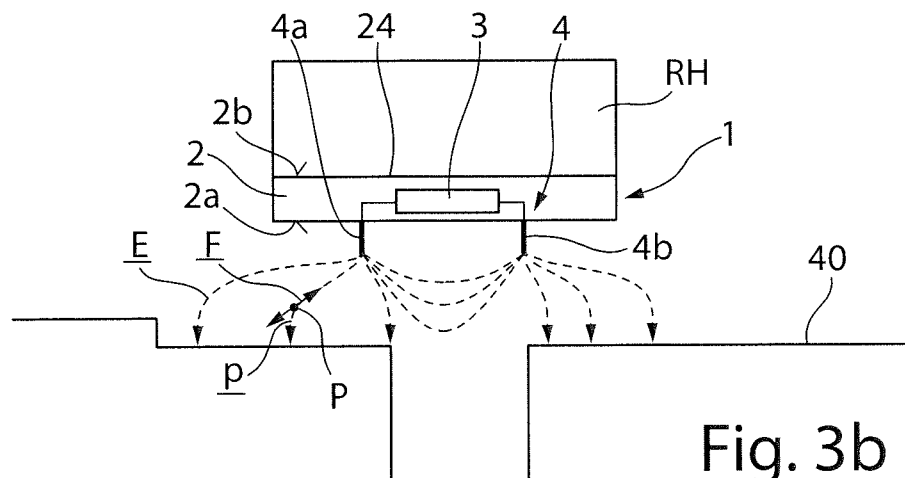


Fig. 3b

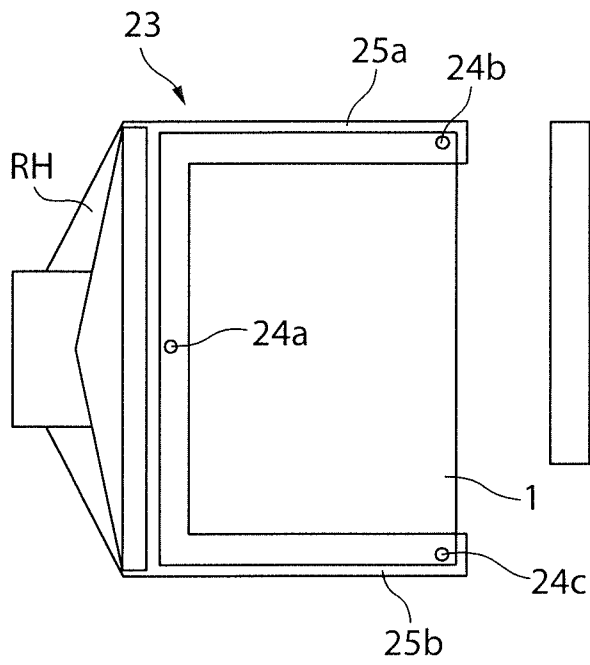


Fig. 4

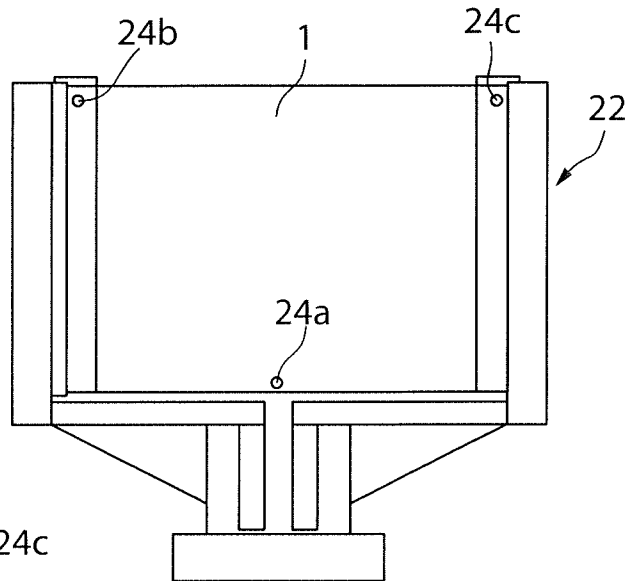


Fig. 5

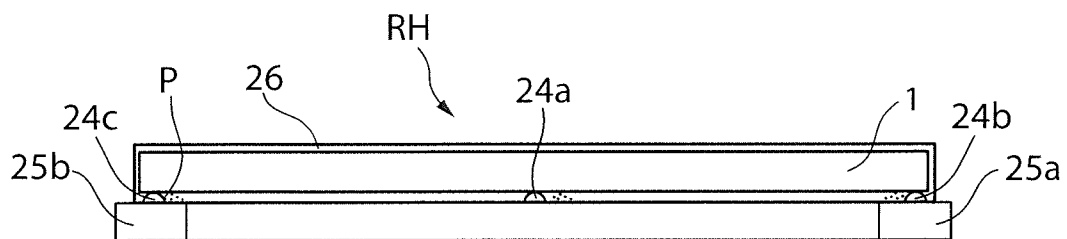


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/054889

A. CLASSIFICATION OF SUBJECT MATTER
INV. G03F7/20
ADD.

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)
G03F

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2004/180271 A1 (ENLOE DAN [US]) 16 September 2004 (2004-09-16) abstract figures 1(b),2,3(c) paragraphs [0001], [0004], [0024] - [0026], [0038] - [0068], [0013] -----	1-5, 11-16 6-10
X	JP 2010 045317 A (TOPPAN PRINTING CO LTD) 25 February 2010 (2010-02-25) abstract figures 1-3,7,8 paragraphs [0001], [0004], [0005], [0019] - [0030], [0036] - [0038] -----	1,11-16
A	JP 2009 016422 A (NIPPON KOGAKU KK) 22 January 2009 (2009-01-22) abstract figures 1,2 paragraphs [0001], [0011] - [0020] -----	1-16



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

30 May 2016

Date of mailing of the international search report

10/06/2016

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/054889

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		US 2004180271 A1	16-09-2004

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JP 2009016422 A	22-01-2009	NONE	
