System and method for a wet chemical treatment of a substrate surface

Technical field

This disclosure relates to a system for a wet chemical treatment of a substrate surface and a method for a wet chemical treatment of a substrate surface.

Background

Many industrial production processes, especially in the very complex and atomic-scale sensitive semiconductor device industry, require the ability to accurately, sometimes abruptly stop the processing at a very specific time. This time is in most cases determined by the achievement of a certain layer thickness of a material grown or partially removed (thinned), or completely removed from a surface of a substrate. The surface of the substrate can be fully covered with a subject material layer or be partially structured, meaning not fully covered or covered by (regular or irregular) patterns. To achieve a highly accurate stopping of such processes, very often thickness control is required close to atomic range, but currently more often in the several nanometer range. Usually, a timed approach is being used in many industries. This means, the time at which the process has to be stopped is determined through an experimental approach. After this, the process is controlled to the tightest specifications possible. However, especially for layer removal (e.g. etching) processes, in which only a very well-defined amount of material is permitted to be removed, slight variations in chemical concentrations or temperature can lead to very significant and unacceptable results. In these cases, accurate process end-point control is only possible with a highly accurate end-point detection system. It is especially required that a successfully implementable end-point detection system is compatible with the chemicals being applied for the processing, as in most cases, very harsh chemical environments are required, so that the chemical environment does not cause a shift in the end-point detection signal.

Methods of end-point detection for etching processes are known. Some of them are based on laser interferometry or optical emission spectroscopy, which monitor the interference of light

reflected from thin films as they are being etched, or the optical emission respectively. They use similar techniques, but different light sources. Laser interferometry uses a laser beam, such as a helium-neon laser, as a light source, whereas optical emission uses light from plasma emissions in a plasma reaction chamber as the light source.

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However, these known end-point detection systems are only useful for dry etching processes, e.g., plasma or reactive ion etching. If they are used for wet etching processes, with liquid chemicals (acids, bases, oxidizers etc.), the signal source and the signal detection systems are located at a pre-determined distance away from the liquid surface, where it is necessary to
10 ensure a constant thickness of the wet etchant to suppress unwanted interference effects. Such systems require so-called horizontal chemical spin-systems to be able to control the thickness and shape of the liquid chemical layer through the spin speed adjusted to the liquid viscosity. In one example, an etch apparatus accommodates a substrate having one or more thin films thereon to be wet etched to remove one or more of the films from one side only (front side or
15 backside) using some etch solutions. Such apparatus is employed to remove thin films from one side of a substrate such as a silicon wafer, particularly from the backside, but also from the front side. A flow of wet etchant is supplied to that side of the wafer, which faces up. By spinning the wafer, a film of wet etchant is formed whose thickness varies irregularly. The incoming light beam will be partially reflected at the air-liquid film interface, at the liquid-
20 solid film interface, and at the solid film-underlying substrate interface, which effects must be compensated through challenging physical assumptions and mathematical models.

Summary

Hence, there may be a need to provide an improved system and method for a wet chemical
25 treatment of a substrate surface, which allows an easier control of the wet chemical treatment of the substrate surface.

The objective of the present disclosure is solved by the subject-matters of the independent claims, wherein further embodiments are incorporated in the dependent claims. It should be
30 noted that the aspects of the disclosure described in the following apply to the system for a wet chemical treatment of a substrate surface and the method for a wet chemical treatment of

a substrate surface.

According to the present disclosure, a system for a wet chemical treatment of a substrate surface is presented. The system for a wet chemical treatment of a substrate surface comprises a radiation source configured to provide a first electromagnetic radiation. The system further comprises a distribution body comprising at least jet holes, wherein the jet holes are configured to distribute a wet chemical relative to the substrate surface. The system further comprises at least a wave-guide module, wherein the wave-guide module is configured to guide the first radiation from the radiation source through the distribution body. The system further comprises a sensor element configured to detect a second radiation, which is the reflection of the first radiation at the substrate surface. The wave-guide module is further configured to guide also the second radiation through the distribution body and to the sensor element.

This structure may allow the present system for wet chemical treatment of a substrate surface to get along without the pre-determined distance (described above in the prior art chapter) between the wet chemical surface and the radiation source on the one hand and the sensor element on the other hand. In contrast to the prior art, radiation source and sensor element may need not to be located distant from the wet chemical surface to ensure a constant thickness of the wet chemical to suppress unwanted interference effects. Consequently, the present system for wet chemical treatment of a substrate surface may not require the above-described horizontal chemical spin-systems to be able to control the wet chemical layer through the spin speed adjusted to the wet chemical viscosity. Finally, the above-described challenging physical assumptions and mathematical models may not be required. The second radiation provides information on the substrate surface and can be used as basis to control the wet chemical treatment of the substrate surface. As a result, an improved system for a wet chemical treatment of a substrate surface may be achieved, which may allow an easier control of the wet chemical treatment of the substrate surface. Surprisingly, this outcome may be achieved by using (only) the already existing distribution body to guide the first and second radiation.

The wet chemical treatment may be a material removal (as e.g. an etching) or a material deposition (as e.g. a plating). The wet chemical may be an etchant and/or an electrolyte. The

substrate may be a wafer, a panel or the like. The substrate surface may be a wafer surface.

The radiation source may be an LED or a halogen lamp. The provided first electromagnetic radiation may be light, in particular a light beam. The first electromagnetic radiation may have a single wavelength, several wavelengths or may comprise a spectrum. The same applies for the second electromagnetic radiation, which is the reflection of the first radiation at the substrate surface.

The distribution body comprising at least jet holes. The jet holes may control a flow of the wet chemical towards the substrate surface. The jet holes may have a structure or form to increase a speed of the wet chemical, e.g. a tip or a nozzle. The number of jet holes can be 100 or more. The jet holes may direct the wet chemical perpendicular away from a main surface of the distribution body. The main surface of the distribution body can be understood as the surface, which is facing the substrate when it is treated.

The jet holes may be commonly fed by an inner volume of the distribution body (a so-called distribution volume). Consequently, the jet holes connect the inner volume of the distribution body with the volume between the distribution body and the substrate surface when treated. The jet holes may extend partially through (not along) the distribution body. The jet holes may direct the wet chemical perpendicular to a cross-section of the distribution body. The cross section can be understood as parallel to the main surface of the distribution body.

The wave-guide module may comprise a part of the distribution body. The sensor element can be understood as a signal receiver and may be a spectrometer or the like. The second radiation received by the sensor element may provide information on the substrate surface (surface property data) and can be used as basis to control the wet chemical treatment of the substrate surface. Also, a comparison between the first and the second radiation can be used for this purpose.

In an embodiment, the wet chemical treatment is an etching process. The wet chemical may be an etchant. The sensor element may be further configured to analyze surface property data of the substrate surface provided by the at least second radiation to determine an end of the

etching process. As a result, a system for determining an end-point of a wet chemical etching process can be provided, eliminating a need for a complex and difficult control of the wet chemical layer thickness. At the substrate surface, the wet chemical is changing a surface composition and/or layer thickness, which affects the reflection of the first radiation, which is called the second radiation. This process dependent, reflection may be guided through the wave-guide module to the sensor element, which may detect and analyze surface property data (e.g. material properties and/or thickness specific information) contained in the reflected first radiation, which is the second radiation, and may permit an interpretation of the processing status in-situ and in real time. As a result, a highly accurate end-point detection system for layer removal (e.g. etching) processes can be achieved, by which only a very well-defined amount of material can be removed.

In an embodiment, the first radiation and/or the second radiation are/is guided through transparent or translucent part(s) of the distribution body. This might avoid the use of additional components and/or saves space. The at least one transparent or translucent part of distribution body or most of or the entire distribution body can be made of a material configured to at least partially transmit radiation with a specific wavelength or multiple wavelengths or an electromagnetic spectrum out of a range of 100 nm – 2000 nm, preferably 200 nm - 1500 nm, more preferably 300 nm - 1000 nm, even more preferably 400 nm - 750 nm. At least portions of these ranges can be transmitted. The at least one transparent or translucent part of distribution body or most or the entire distribution body can be made of transparent or translucent plastic material. The transparent or translucent plastic material can be transparent or translucent polymer material, preferably transparent or translucent PMMA (poly(methyl methacrylate)) material. The at least one transparent or translucent part of distribution body or most or the entire distribution body can be considered as part of the wave-guide module.

The transparent or translucent part of the distribution body through which the first radiation and/or the second radiation are/is guided (with the above-described characteristics), can be a pipe or tower shaped part of the distribution body. In other words, the wave-guide module may comprise, when seen in a cross section, a pipe or tower shaped part of the distribution body. The cross section can be understood as parallel to the main surface of the distribution body. The pipe shaped part of the distribution body may form a connecting passage to guide

the first radiation from the radiation source through the distribution body (and to the substrate surface, if present) and/or to guide the second radiation (from the substrate surface, if present) through the distribution body to the sensor element.

In an embodiment, the first radiation and/or the second radiation are/is guided through a guide hole in the distribution body. This might ease the guidance of the first radiation and/or the second radiation through the distribution body. The guide hole can be arranged to be directed through the transparent or translucent part of distribution body. Otherwise, the guide hole can be alternatively to the transparent or translucent part of distribution body. The guide hole can be considered as part of the wave-guide module. There can be one or more guide hole(s). There can be a first guide hole for the first radiation and a second guide hole for the second radiation. There can be a plurality of guide holes to increase the amount of transmitted radiation.

A guide hole can also be accompanied by one or more pipe or tower shaped part(s) of the distribution body. In particular, a guide hole can be surrounded by several or a plurality of pipe/tower shaped parts arranged next to each other, adjacent, and in stages. The closer or nearer a single pipe/tower shaped part is to the fiber, the more radiation is guided or channeled through this respective pipe/tower shaped part. There might be only one pipe/tower shaped part per fiber, but also two or more pipe/tower shaped parts per fiber can be used to guide more radiation.

In an embodiment, the guide hole in the distribution body is one of the jet holes. This avoids the necessity of an additional hole to the minimum configuration of the system for a wet chemical treatment of a substrate surface.

In an embodiment, the guide hole in the distribution body is a drain hole configured to drain the wet chemical from the substrate surface. The drain hole is another option and avoids the necessity of an additional hole if the drain hole is already present for e.g. the draining purpose. The drain hole may extend through a cross section of the distribution body, connecting opposite faces thereof in a through-hole form. The cross section can be understood as parallel to the main surface of the distribution body. More information to the drain hole is

provided further below.

In an embodiment, the guide hole in the distribution body is a separate hole. Separate hole means that it is neither a jet hole nor a drain hole. This embodiment allows designing the guide hole exactly to the purpose of guiding the first and/or second radiation without taking into consideration other purposes, as e.g. flow control or draining. A separate hole may have a larger diameter than a jet hole, preferably at least 1.5 times the size of a jet hole, more preferably at least double the size of a jet hole. A separate hole may have a larger diameter than a drain hole, preferably at least1.5 times the size of a drain hole, more preferably at least double the size of a drain hole.

Of course, in each of these cases, there can be again more than one guide hole, either of one kind or even a mixture of kinds. This means there can be, at the same time, guide holes in form of jet hole(s), drain hole(s) and/or separate hole(s). The guide hole(s) can be combined with the transparent or translucent (entire, part or pipe/tower of the) distribution body.

The system for a wet chemical treatment of a substrate can be applied for electroless wet chemical treatments and for electrochemical wet chemical treatments. In an embodiment, the system for a wet chemical treatment of a substrate is also a system for an electrochemical treatment of the substrate surface. The electrochemical treatment may be an etching. The wet chemical may be an etchant. The distribution body may comprise drain holes. The drain holes may be configured to distribute an electric potential relative to the substrate surface. Electrochemical wet chemical treatments can be more efficient than electroless wet chemical treatments. The drain holes may further improve the efficiency and/or increase the uniformity of the wet chemical treatment and in particular the etching.

As already stated above, the drain holes may be also configured to drain the wet chemical from the substrate surface. The drain holes may have a structure to provide a single way etchant distribution away from the substrate surface. Thereby, the drain holes may further improve the efficiency and/or increase the uniformity of the wet chemical treatment and in particular the etching. The drain holes may extend through a cross section of the distribution body, connecting opposite faces thereof in a through-hole form. The cross section can be

understood as parallel to the main surface of the distribution body. Additionally, at least one of the drain holes may be the or a guide hole.

A distribution body comprising jet holes and drain holes can be referenced to as high speed processing (HSP) distribution system, which may direct the wet chemical with high and controllable speed towards the substrate surface to be processed (and back). The HSP may further distribute the wet chemical and an electric potential over the substrate surface in a controlled and optimized way.

In an embodiment, the wave-guide module comprises a first fiber leading from the radiation source to the distribution body. In case the radiation source is arranged in or in contact with the distribution body, the first fiber can be omitted. The wave-guide module may comprise a separate second fiber leading from the distribution body to the sensor element. The first fiber may guide the first radiation from the radiation source to a substrate surface. The second fiber may guide the second radiation from the substrate surface to the sensor element. The first and the second fiber are not the same element. At the substrate surface, a wet chemical may change a surface composition and/or layer thickness of the substrate surface, which may influence a reflection of the first radiation. This process dependent, reflected first radiation, which is the second radiation, may be guided through the second fiber to the sensor element. The sensor element may detect and/or analyze e.g. a material property and/or thickness specific information contained in the second radiation. This may permit an interpretation of the processing status in-situ and in real time. The sensor element (e.g., a signal receiver situated external of a process chamber) may receive the second radiation via the second fiber.

In another embodiment, the wave-guide module comprises a combined fiber leading from the radiation source to the distribution body and from the distribution body to the sensor element. The combined fiber is only one fiber fulfilling the functions of the first and the second fibers together. This might be beneficial for extreme space constrained environments. The sensor element may be part of the radiation source. The radiation source and the sensor element may be configured for pulsed signals. There can be a splitter element as e.g. a prism. The radiation source and the sensor element may be arranged outside a wet chemical treatment chamber

holding the distribution body.

The first fiber, the second fiber and/or the combined fiber can be led through the transparent or translucent (entire, part or pipe/tower of the) distribution body and/or through a guide hole (in form of a jet hole, drain hole or separate hole).

In an embodiment, the first fiber, the second fiber and/or the combined fiber is/are acid resistant fiber(s). The first fiber, the second fiber and/or the combined fiber may comprise glass and/or plastic, preferably polymer material, more preferably PMMA (poly(methyl methacrylate)) material. A plastic fiber may be of advantage for narrow (space constrained) integration, as it allows a lower bending radius. The bending radius may be further improved by heating the fiber. The first fiber, the second fiber and/or the combined fiber may be provided with a collimating lens. The first fiber, the second fiber and/or the combined fiber may have a diameter in a range of 1.5 to 0.1 mm, preferably 1 to 0.3 mm, more preferably 0.7 to 0.5 mm. If the fiber is directed through a drain hole, the fiber diameter should have the same or a smaller diameter than the drain hole (e.g. a fiber with a diameter of 0.6 mm requires a drain hole having at least a diameter of 0.6 mm). If the fiber has the same diameter as the drain hole it is clear that in such instance the drain hole does not have the function of a drain hole but is purely dedicated for embedding the fiber (e.g. the second fiber).

Of course, there can be more than one, several or a plurality of “first fibers”, “second fibers” and/or “combined fibers” to measure at more than one, several or a plurality of measuring points to improve the measuring accuracy and/or the surface treatment quality and/or uniformity.

In an embodiment, the radiation source is integrated into the distribution body. There might then be no distance between the radiation source and the wet chemical. The first fiber can be omitted. In another embodiment, the radiation source is separate and distinct to the distribution body. The radiation source may be within or outside a wet chemical treatment chamber holding the distribution body. The radiation source within the wet chemical treatment chamber may be either a distribution body integrated radiation source or a radiation source adjacent or “behind” the distribution body. “Behind” can be understood as behind

when seen from the area where the substrate would be placed during treatment. The radiation source outside the wet chemical treatment chamber may use the combined fiber leading from the radiation source to the distribution body and from the distribution body to the sensor element. The sensor element may be part of the radiation source. This might be beneficial for extreme space constrained environments. The radiation source and the sensor element may be configured for pulsed signals.

In an embodiment, radiation-transmitting surfaces of the distribution body are polished, preferably to a roughness in a range of 3 µm – 0.02 µm Ra, preferably in a range of 2 µm – 0.1 µm Ra. The polished surfaces may further enhance the optical characteristics of the transmitting surfaces and properties of (these parts of) the distribution body.

In an embodiment, the radiation source is configured to provide the first radiation with an electromagnetic spectrum with a peak at 458 nm (+/- 10 nm) or at 540 nm (+/- 10 nm). In an embodiment, the sensor element is configured to detect the second radiation with an electromagnetic spectrum in a range of 200 to 1100 nm, preferably 400 to 800 nm, more preferably 500 to 700 nm.

In an embodiment, the system for a wet chemical treatment of a substrate surface further comprises a substrate holder. The substrate holder can be configured to hold the substrate parallel to the main surface of the distribution body. The main surface can be understood as the surface, which is facing the substrate when it is treated. The substrate holder and the substrate can be horizontally arranged, wherein “horizontally” is meant relative to the floor. This arrangement is suitable e.g. for very large panels (e.g. 1 m x 1 m). In an alternative, the substrate holder is a vertically arranged substrate holder configured to hold the substrate vertically next to the vertically arranged distribution body. “Vertically” means relative to the floor. The distribution body and wave-guide module can be inserted through a chamber wall opening or from a top opening of the chamber for a wet chemical treatment. The substrate holder might be configured to hold a substrate only on one of its sides. The substrate holder might also be configured to hold one substrate on its front side and another substrate on its backside (double-sided substrate holder).

The substrate holder may be configured to hold the substrate. The substrate holder may be a single component for holding the substrate, but may be also a part of the anode (in case of material removal as e.g. etching) to place the substrate directly onto the anode. The substrate holder may have any size and shape suitable for holding any kind of substrate. The substrate holder, next to holding the substrate stably, may provide an anode function by providing electric potential directly to the substrate. Electrons from the electrically conductive material at the surface of the substrate can be extracted through a potential being applied. The substrate holder may be electrically connected to a positive pole of a source of direct electric current (in case of material removal as e.g. etching, for material deposition vice versa). The substrate holder may comprise a plurality of electric contacts for the substrate. A cathode may be electrically connected to a negative pole of the source of direct electric current (in case of material removal as e.g. etching, for material deposition vice versa). The cathode may be positioned on one side of the distribution body opposite the side facing the substrate when processed.

In an embodiment, the substrate holder is stationary and configured to hold the substrate without rotational spinning during the wet chemical treatment. This does not exclude rotational agitation (slight back and forth movement) to improve the chemical treatment of the substrate surface. This does exclude full and/or repeated spinning of the substrate holder and the substrate as described to the prior art in view of the horizontal chemical spin-systems to be able to control the wet chemical layer through the spin speed.

The system for a wet chemical treatment of a substrate surface may further comprise a reservoir or a bath for containing the wet chemical. The wet chemical may be specifically optimized for the material to be treated. The bath may be configured so that the substrate can be fully immersed.

According to the present disclosure, also a method for a wet chemical treatment of a substrate surface is presented. The method for a wet chemical treatment of a substrate surface comprises, not necessarily in this order:

- distributing a wet chemical relative to the substrate surface by means of jet holes provided in a distribution body,

- providing a first electromagnetic radiation by means of a radiation source,
- guiding the first radiation from the radiation source through the distribution body by means of a wave-guide module,
- guiding a second radiation, which is the reflection of the first radiation at the substrate surface, by means of the wave-guide module through the distribution body and to a sensor element, and
- detecting the second radiation by means of the sensor element.

An improved method for a wet chemical treatment of a substrate surface may be achieved, which may allow an easier control of the wet chemical treatment of the substrate surface. The second radiation can be used as basis for information on the substrate surface to control the wet chemical treatment of the substrate surface. Surprisingly, this may be achieved by using (only) the already existing distribution body to guide the first and second radiation. The present method for wet chemical treatment of a substrate surface may neither require the horizontal chemical spin-system nor the challenging physical assumptions and mathematical models described with reference to the prior art.

In an embodiment, the wet chemical treatment is an etching process. It may further comprise:

- analyzing surface property data of the substrate surface provided by the at least second radiation to determine an end of the etching process.

The method for a wet chemical treatment of a substrate may also be a method for an electrochemical treatment of the substrate surface. The wet chemical may be an etchant. The distribution body may comprise drain holes. The drain holes may be configured to distribute an electric potential relative to the substrate surface. Thereby, the drain holes may further improve the etching. As already stated above, the drain holes may be also configured to drain the wet chemical from the substrate surface. The drain holes may have a structure to provide a single way etchant distribution away from the substrate surface. Thereby, the drain holes may further improve the efficiency and/or increase the uniformity of the wet chemical treatment and in particular the etching. A drain hole may have an orifice with a cross-sectional area of at least double the size of a cross-sectional area of an orifice of a jet hole. For example, if the cross-sectional area of the orifice of the jet hole is 0.1 mm^2, the cross-sectional area of the orifice of the drain hole would be at least 0.2 mm^2.

A processing unit (e.g. a computer) may determine or calculate an end of the wet chemical treatment (e.g. the etching process) based on the analyzed surface property data (e.g. material properties and/or thickness specific information) of the substrate surface. The surface property data was analyzed or found based on at least the second radiation and optionally also based a comparison between the second radiation and the first radiation. Some experience-based factor might be added to the calculated end of the wet chemical treatment to obtain a real finishing point of time for the wet chemical treatment. The second radiation data used to obtain the surface property data may be an intensity of the reflected signal over time. Not only the intensity as direct signal can be used, but the signal can also be damped and/or a derivative signal can be used (e.g. first derivative, second derivative). The end of the wet chemical treatment can be defined to be reached when e.g. the intensity passes a particular threshold or reaches a particular slope. The endpoint detection can be based on e.g. reflection or ellipsometry. The endpoint of the wet chemical treatment can be outputted as a duration from start, e.g. 49.5 seconds.

It shall be understood that the system and the method according to the independent claims have similar and/or identical preferred embodiments, in particular, as defined in the dependent claims. It shall be understood further that a preferred embodiment of the disclosure can also be any combination of the dependent claims with the respective independent claim.

These and other aspects of the present disclosure will become apparent from and be elucidated with reference to the embodiments described hereinafter.

Brief description of the drawings

Exemplary embodiments of the disclosure will be described in the following with reference to the accompanying drawing:

Figures 1a and 1b show schematically and exemplarily an embodiment of a system for a wet chemical treatment of a substrate surface according to the disclosure.

Figure 2 shows schematically and exemplarily an embodiment of a system for a wet chemical treatment of a substrate surface according to the disclosure.

Figure 3 shows schematically and exemplarily an embodiment of a system for a wet chemical treatment of a substrate surface according to the disclosure.

Figure 4 shows schematically and exemplarily an embodiment of a system for a wet chemical treatment of a substrate surface according to the disclosure.

Figures 5a and 5b show schematically and exemplarily details of an embodiment of a system for a wet chemical treatment of a substrate surface according to the disclosure.

Figure 6 shows schematically and exemplarily a detail of an embodiment of a system for a wet chemical treatment of a substrate surface according to the disclosure.

Figure 7 shows schematically and exemplarily an embodiment of a method for a wet chemical treatment of a substrate surface according to the disclosure.

Detailed description of embodiments

Figures 1a and 1b show schematically and exemplarily an embodiment of a system 10 for a wet chemical treatment of a substrate surface 41 according to the disclosure. The wet chemical treatment is here a material removal as e.g. an etching. The substrate 4 may be a wafer or a panel. The substrate surface 41 may be a wafer surface. A substrate holder 42 holds the substrate 4.

The system 10 for a wet chemical treatment of a substrate surface 41 comprises a radiation source 11 to provide a first electromagnetic radiation 12. The radiation source 11 may be an LED or a halogen lamp. The provided first electromagnetic radiation 12 may be light, in particular a light beam. The first electromagnetic radiation 12 may have a single electromagnetic wavelength, several electromagnetic wavelengths or may comprise a spectrum of electromagnetic wavelengths.

The system 10 further comprises a HSP distribution body 13 comprising jet holes 14. The jet holes 14 are configured to distribute a wet chemical 30 relative to the substrate surface 41.

The jet holes 14 have a form to increase a speed of the wet chemical 30. The jet holes 14 extend at least partially through a cross section of the distribution body 13. The cross section can be understood as parallel to a main surface of the distribution body 13. The main surface can be understood as the surface, which is facing the substrate 4 when it is processed.

The jet holes 14 (see Figure 1b) connect an inner volume 25 of the distribution body 13 with one face of the distribution body 13, which faces the substrate 4, when treated. The inner volume 25 of the distribution body 13 is pressurized so that the wet chemical 30 is jetted towards the substrate surface 41. The wet chemical 30 is laterally fed into the inner volume 25 for example from an edge of the distribution body 13 e.g. from above, below or aside. The jet holes 14 may only connect e.g. a "shower head plate" of the distribution body 13 with a volume 26 between the distribution body 13 and the substrate 4 when treated. The shower head plate can be understood as a plate comprising a plurality of jet holes 14 configured to face towards the substrate 4 when treated. Here, the jet holes 14 are supplied with the wet chemical 30 from a liquid intake of the distribution body 13. The jet holes 14 are open to the inner volume 25 and directed to the substrate 4 when treated. The axes of jet holes 14 are essentially perpendicular to the first side.

The system 10 further comprises a sensor element 16 to detect a second radiation 17. The sensor element 16 can be understood as a signal receiver and may be a spectrometer. The second radiation 17 is the reflection of the first radiation 12 at the substrate surface 41.The second electromagnetic radiation may be light, in particular a light beam. The second electromagnetic radiation may have a single electromagnetic wavelength, several electromagnetic wavelengths or may comprise a spectrum of electromagnetic wavelengths. The radiation source 11 and the sensor element 16 are housed together in a source-receiver module 24.

The system 10 further comprises at least a wave-guide module 15. The wave-guide module 15 comprises at least a part of the distribution body 13. The wave-guide module 15 is configured to guide the first radiation 12 from the radiation source 11 through the distribution body 13. The wave-guide module 15 is further configured to guide also the second radiation 17 through the distribution body 13 and to the sensor element 16.

The first radiation 12 and the second radiation 17 are guided through transparent parts 18 of the distribution body 13. Either only these transparent parts 18 of distribution body 13 or most of or the entire distribution body 13 can be made of transparent plastic material. The transparent plastic material can be transparent polymer material, preferably transparent PMMA. The transparent part of or the transparent most of or the transparent entire distribution body 13 can be considered part of the wave-guide module 15. Radiation-transmitting surfaces 23 of the distribution body 13 can be polished to a roughness in a range of 3 µm – 0.02 µm Ra.

The transparent parts 18 of the distribution body 13 through which the first radiation 12 and/or the second radiation 17 are guided, are here tower or pipe shaped parts 19 of the distribution body 13. The pipe shaped parts 19 of the distribution body 13 form connecting passages to guide 1.) the first radiation 12 from the radiation source 11 through the distribution body 13 and to the substrate surface 41 and to guide 2.) the second radiation 17 from the substrate surface 41 through the distribution body 13 to the sensor element 16.

The first radiation 12 and the second radiation 17 are not only guided by the parts of the distribution body 13, but also let through by guide holes 20 in the distribution body 13. The guide holes 20 can be considered as part of the wave-guide module 15. There is a first guide hole 20 for the first radiation 12 and a second guide hole 20 for the second radiation 17. There can even be a plurality of guide holes 20 to increase the amount of transmitted radiation.

The guide holes 20 in the distribution body 13 can be jet holes 14 and/ or drain holes 21. The drain holes 21 are configured to drain the wet chemical 30 from or off the substrate surface 41. The drain holes 21 extend through the cross section of the distribution body 13, connecting opposite faces thereof in a through-hole form. The cross section can be again understood as parallel to the main surface of the distribution body 13. The drain holes 21 may be further configured to distribute an electric potential relative to the substrate surface 41. The drain holes 21 are formed by pipes leading from one face of the distribution body 13 to the opposite side of the distribution body 13. The pipe separates an inner part of the drain hole from an inner volume 25 of the distribution body 13, which feeds the jet holes14.

The guide holes 20 in the distribution body 13 can also be separate holes 22. Separate hole 22 means that it is neither a jet hole 14 nor a drain hole 21. Of course, there can be, at the same time, guide holes 20 in form of jet holes 14, drain holes 21 and/or separate holes 22. The guide holes 20 can be combined with the transparent (part or pipe shaped part 19 of the) distribution body 13.

The wave-guide module 15 comprises a first fiber 32 leading from the radiation source 11 to the distribution body 13. The wave-guide module 15 comprises a separate second fiber 37 leading from the distribution body 13 to the sensor element 16. The first fiber 32 and the second fiber 37 are led through transparent parts 18 and pipe shaped parts 19 of the distribution body 13 and through guide holes 20 (e.g. in form of jet holes 14, drain holes 21 or separate holes 22). The first fiber 32 guides the first radiation 12 from the radiation source 11 to the substrate surface 41. The second fiber 37 guides the second radiation 17 from the substrate surface 41 to the sensor element 16. At the substrate surface 41, the wet chemical 30 changes a surface composition and/or layer thickness of the substrate surface 41, which influences a reflection of the first radiation 12. This process dependent, reflected first radiation 12, which is the second radiation 17, is guided through the second fiber 37 to the sensor element 16. The sensor element 16 detects and/or analyzes e.g. a material property and/or thickness specific information contained in the second radiation 17. This permits an interpretation of the processing status in-situ and in real time. The sensor element 16 (e.g., a signal receiver) receives the second radiation 17 via the second fiber 37.

Here, the wet chemical treatment is an electrochemical treatment of the substrate surface 41 and an etching process. The wet chemical 30 is an etchant. The sensor element 16 is configured to analyze surface property data of the substrate surface 41 provided by the at least second radiation 17 to determine an end of the etching process. The wet chemical 30 is changing a surface composition and/or layer thickness at the substrate surface 41, which affects the reflection of the first radiation 12, which is the second radiation 17. This process dependent reflection is guided through the wave-guide module 15 to the sensor element 16, which detects and analyzes surface property data (e.g. material properties and/or thickness specific information) contained in the second radiation 17. As a result, a highly accurate end-point detection system 10 for an etching process can be achieved, by which only a very well-

defined amount of material can be removed.

The substrate 4 is held in a substrate holder 42, which may provide an anode function by providing electric potential directly to the substrate 4. Electrons from the electrically conductive material at the surface 41 of the substrate 4 can be extracted through a potential being applied. The substrate holder 42 may be electrically connected to a positive pole of a source of direct electric current (in case of material removal as e.g. etching, for material deposition vice versa). The substrate holder 42 may comprise a plurality of electric contacts for the substrate 4. A cathode may be electrically connected to a negative pole of the source of direct electric current (in case of material removal as e.g. etching, for material deposition vice versa).

The substrate holder 42 is vertically arranged to hold the substrate 4 vertically next to the also vertically arranged distribution body 13. The distribution body 13 and wave-guide module 15 can be inserted through a chamber wall opening or from a top opening of the chamber for a wet chemical treatment.

Figure 2 shows schematically and exemplarily an embodiment of a system for a wet chemical treatment of a substrate surface 41 according to the disclosure. The system comprises a radiation source 11 to provide a first electromagnetic radiation 12 (see Figure 1). The radiation source 11 is arranged within a wet chemical treatment chamber holding a transparent distribution body 13. The radiation source 11 is in particular integrated into the distribution body 13. The radiation source 11 may shine through the transparent distribution body 13 and to the substrate surface 41. There is essentially no distance between the radiation source 11 and the wet chemical 30.

The system for a wet chemical treatment of a substrate surface 41 further comprises a sensor element 16 to detect the second radiation 17. The sensor element 16 is arranged distant to the distribution body 13, but still within the wet chemical treatment chamber. The sensor element 16 may be connected to a processing unit configured to calculate an end-point of the wet chemical treatment based on the detected surface property data. The system further comprises a power source 33, 38 distant to the distribution body 13 and e.g. outside the wet chemical

treatment chamber, which is configured to supply power to the radiation source 11 and/or the sensor element 16.

The system for a wet chemical treatment of a substrate surface 41 further comprises a wave-guide module 15 comprising the transparent distribution body 13. The wave-guide module 15 is configured to guide the first radiation 12 (not shown) from the radiation source 11 through the distribution body 13 and to guide a second radiation 17 (not shown) through the distribution body 13 and to the sensor element 16. The second radiation 17 is the reflection of the first radiation 12 at the substrate surface 41. The wave-guide module 15 comprises a guide hole 20 in the distribution body 13. The guide hole 20 in the distribution body 13 is here a separate hole 22. Separate hole 22 means that it is neither a jet hole nor a drain hole. The separate hole 22 has a larger diameter than the jet holes or the drain holes.

As the radiation source 11 is embedded in the guide hole 20 in the distribution body 13 or is attached on the guide hole 20, there is no need for a first fiber 32 to guide the first radiation 12 from the radiation source 11 through the distribution body 13. However, the wave-guide module 15 comprises a second fiber 37 leading from the distribution body 13 to the sensor element 16 to guide the second radiation 17 from the substrate surface 41 to the sensor element 16.

Figure 3 shows schematically and exemplarily an embodiment of a system for a wet chemical treatment of a substrate surface 41 according to the disclosure. The system again comprises a radiation source 11 to provide a first electromagnetic radiation 12 (not shown). The radiation source 11 is here separate and distinct to the distribution body 13. The radiation source 11 is still arranged within the wet chemical treatment chamber holding the distribution body 13, so that the radiation source 11 is arranged adjacent or “behind” the distribution body 13. As a result, the radiation source 11 may shine through the distribution body 13 and to the substrate surface 41. The distribution body 13 comprises jet holes 14 and drain holes 21.

The system for a wet chemical treatment of a substrate surface 41 also comprises a sensor element 16 to detect the second radiation 17. The sensor element 16 is also arranged distant to the distribution body 13, but still within the wet chemical treatment chamber. The sensor

element 16 may be again connected to a processing unit configured to calculate an end-point of the wet chemical treatment based on the detected surface property data. The system further comprises a first power source 33, which is configured to supply power to the radiation source 11 and a second power source 38, which is configured to supply power to the sensor element 16.

The system for a wet chemical treatment of a substrate surface 41 also comprises a wave-guide module 15, which here comprises a first fiber 32 to guide the first radiation 12 from the radiation source 11 through a drain hole 21 in the distribution body 13 and a second fiber 37 to guide the second radiation 17 through a jet hole 14 in the distribution body 13 and to the sensor element 16. The second radiation 17 is the reflection of the first radiation 12 at the substrate surface 41.

Figure 4 shows schematically and exemplarily an embodiment of a system for a wet chemical treatment of a substrate surface 41 according to the disclosure. The system again comprises a radiation source 11 to provide a first electromagnetic radiation 12. The radiation source 11 is here separate and distinct to the distribution body 13. The radiation source 11 is arranged outside the wet chemical treatment chamber holding the distribution body 13. The radiation source 11 may be combined with the sensor element 16 arranged also separate and distinct to the distribution body 13 as well as outside the wet chemical treatment chamber. The radiation source 11 and the sensor element 16 may have a common power source 33, 38.

The wave-guide module 15 comprises here a combined fiber 35 leading from the radiation source 11 through a jet hole 14 in the distribution body 13 and from the distribution body 13 to the sensor element 16. There is no other fiber. The radiation source 11 and the sensor element 16 may be configured for pulsed signals. There can be a splitter element as e.g. a semi-transparent mirror or a prism arranged in the radiation path to submit the returning second radiation to the sensor element 16.

The system for a wet chemical treatment of a substrate surface further comprises a bath 36 for the wet chemical 30. The bath 36 is dimensioned so that the substrate 4 is fully immersed in the wet chemical 30. The substrate 4 is arranged between two distribution bodies 13, here two

distribution plates of a HSP. The substrate 4 is held by a substrate holder, in Figure 4 shown at the upper and lower end of the substrate 4.

Figures 5a and 5b show schematically and exemplarily details of an embodiment of a system for a wet chemical treatment of a substrate surface according to the disclosure. The system is shown in a cross-sectional perspective view. The detailed view of Figure 5a shows a part of a wall of the wet chemical treatment chamber 31 and a part of the distribution body 13 comprising jet holes 14 and drain holes 21. The arrangement of jet holes 14 and drain holes 21 shown on the right side corresponds to the so-called shower head plate of the distribution body 13. A first fiber 32 in a fiber housing 34 enters the wet chemical treatment chamber 31. As can be seen in Figure 5b, radiation sources 11 are arranged around the first fiber 32 close to a free end of the fiber housing 34. The first fiber 32 exits the fiber housing 34 through a window 39. The first fiber 32 extends to the distribution body 13 and enters a guide hole 20.

The first radiation 12 (and not shown the second radiation 17) is guided through transparent pipe/tower shaped parts 19 of the distribution body 13. The pipe shaped parts 19 of the distribution body 13 form connecting passages to guide the first radiation 12 from the radiation source 11 through the distribution body 13 (and to the substrate surface 41). The pipe shaped parts 19 are arranged next to each other, adjacent and parallel to each other. The closer or nearer a single pipe/tower shaped part 19 is to the fiber 32, the more radiation is guided or channeled through this respective pipe/tower shaped part 19. There might be only one pipe/tower 19 per fiber 32, but also two or more pipes/towers 19 per fiber 32 can be used to guide more radiation to the substrate surface 41. In the shown case, where more than one pipe/tower shaped part 19 is used, the intensity of light is highest in the pipes/tower shaped parts 19 surrounding the light path and in decreasing in the pipes/tower shaped parts 19 with increasing distance to the light path.

Figure 6 shows schematically and exemplarily a detail of an embodiment of a system for a wet chemical treatment of a substrate surface 41 according to the disclosure. Figure 6 shows a transparent distribution body 13, which allows a radiation source 11 (not shown) to shine through the transparent distribution body 13 and to the substrate surface 41(also not shown). In particular, the radiation is (at least partly) transmitted through the wet chemical 30 in the inner volume 25 of the distribution body 13.

Figure 7 shows schematically and exemplarily an embodiment of a method for a wet chemical treatment of a substrate surface 41 according to the disclosure. The method comprises the following steps:

In step S1, distributing a wet chemical 30 relative to the substrate surface 41 by means of jet holes 14 provided in a distribution body 13.

In step S2, providing a first electromagnetic radiation 12 by means of a radiation source 11.

In step S3, guiding the first radiation 12 from the radiation source 11 through the distribution body 13 by means of a wave-guide module 15.

In step S4, guiding a second radiation 17, which is the reflection of the first radiation 12 at the substrate surface 41, by means of the wave-guide module 15 through the distribution body 13 and to a sensor element 16.

In step S5, detecting the second radiation 17 by means of the sensor element 16.

Optionally also:

In step S6, analyzing surface property data of the substrate surface 41 provided by the at least second radiation 17 to determine an end of the etching process.

The method for a wet chemical treatment can be a method for an electrochemical treatment of the substrate surface 41. The wet chemical 30 is then an etchant. The distribution body 13 comprises drain holes 21 to distribute an electric potential relative to the substrate surface 41 and to drain the wet chemical 30 from the substrate surface 41.

A processing unit, as e.g. a computer, calculates an end of the etching process based on analyzed surface property data (e.g. material properties and/or thickness specific information) of the substrate surface 41. The surface property data was analyzed or found based on at least the second radiation 17 and optionally also based a comparison between the second radiation 17 and the first radiation 12.

It has to be noted that embodiments of the disclosure are described with reference to different subject matters. In particular, some embodiments are described with reference to method type

claims whereas other embodiments are described with reference to the device type claims. However, a person skilled in the art will gather from the above and the following description that, unless otherwise notified, in addition to any combination of features belonging to one type of subject matter also any combination between features relating to different subject matters is considered to be disclosed with this application. However, all features can be combined providing synergetic effects that are more than the simple summation of the features.

While the disclosure has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. The disclosure is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing a claimed disclosure, from a study of the drawings, the disclosure, and the dependent claims.

In the claims, the word “comprising” does not exclude other elements or steps, and the indefinite article “a” or “an” does not exclude a plurality. A single processor or other unit may fulfil the functions of several items re-cited in the claims. The mere fact that certain measures are re-cited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

Claims

1. A system (10) for a wet chemical treatment of a substrate surface (41), comprising:
   - a radiation source (11) configured to provide a first electromagnetic radiation (12),
   - a distribution body (13) comprising at least jet holes (14), wherein the jet holes (14) are configured to distribute a wet chemical (30) relative to the substrate surface (41),
   - at least a wave-guide module (15), wherein the wave-guide module (15) is configured to guide the first radiation (12) from the radiation source (11) through the distribution body (13), and
   - a sensor element (16) configured to detect a second radiation (17), which is the reflection of the first radiation (12) at the substrate surface (41),
   - wherein the wave-guide module (15) is further configured to guide also the second radiation (17) through the distribution body (13) and to the sensor element (16).

2. The system (10) according to claim 1, wherein the wet chemical treatment is an etching process, and wherein the sensor element (16) is further configured to analyse surface property data of the substrate surface (41) provided by the at least second radiation (17) to determine an end of the etching process.

3. The system (10) according to one of the preceding claims, wherein the first radiation (12) and/or the second radiation (17) are/is guided through a transparent part (18) of the distribution body (13) or a guide hole (20) in the distribution body (13).

4. The system (10) according to the preceding claim, wherein the guide hole (20) in the distribution body (13) is one of the jet holes (14), a drain hole (21) configured to drain the wet chemical (30) from the substrate surface (41) or a separate hole (22).

5. The system (10) according to one of the preceding claims, wherein the system (10) for a wet chemical treatment of a substrate (4) is also a system for an electrochemical treatment of the substrate surface (41), and wherein the distribution body (13) comprises drain holes (21), which are also configured to distribute an electric potential relative to the substrate surface (41).

6. The system (10) according to one of the preceding claims, wherein the distribution body (13) is made of a material configured to at least partially transmit radiation with an electromagnetic spectrum in a range of 100 nm – 2000 nm, preferably transparent plastic material, more preferably transparent polymer material, even more preferably transparent PMMA (poly(methyl methacrylate)) material.

7. The system (10) according to one of the preceding claims, wherein the wave-guide module (15) comprises, when seen in a cross section, a pipe shaped part (19) of the distribution body (13), wherein the pipe shaped part (19) of the distribution body (13) is made of a transparent plastic material.

8. The system (10) according to one of the preceding claims, wherein the wave-guide module (15) comprises a first fiber (32) leading from the radiation source (11) to the distribution body (13) and/or a separate second fiber (37) leading from the distribution body (13) to the sensor element (16).

9. The system (10) according to one of the claims 1 to 7, wherein the wave-guide module (15) comprises a combined fiber (35) leading from the radiation source (11) to the distribution body (13) and from the distribution body (13) to the sensor element (16), wherein the sensor element (16) is part of the radiation source (11), and wherein the radiation source (11) and the sensor element (16) are configured for pulsed signals.

10. The system (10) according to one of the two preceding claims, wherein the fibre(s) (32, 37) is/are (an) acid resistant glass or plastic fibre(s), preferably with a collimating lens.

11. The system (10) according to one of the preceding claims, wherein the radiation source (11) is integrated into the distribution body (13) or separate and distinct to the distribution body (13), either within or outside a wet chemical treatment chamber (31) holding the distribution body (13).

12. The system (10) according to one of the preceding claims, wherein radiation-transmitting surfaces (23) of the distribution body (13) are polished to a roughness in a range of 3 µm – 0.02 µm Ra.

13. The system (10) according to one of the preceding claims, wherein the radiation source (11) is configured to provide the first radiation (12) with a peak at 458 nm or at 540 nm.

14. The system (10) according to one of the preceding claims, further comprising a vertically arranged substrate holder (42) configured to hold the substrate (4) vertically next to the vertically arranged distribution body (13).

15. A method for a wet chemical treatment of a substrate surface (41), comprising:

- distributing a wet chemical (30) relative to the substrate surface (41) by means of jet holes (14) provided in a distribution body (13),
- providing a first electromagnetic radiation (12) by means of a radiation source (11),
- guiding the first radiation (12) from the radiation source (11) through the distribution body (13) by means of a wave-guide module (15),
- guiding a second radiation (17), which is the reflection of the first radiation (12) at the substrate surface (41), by means of the wave-guide module (15) through the distribution body (13) and to a sensor element (16), and
- detecting the second radiation (17) by means of the sensor element (16).

16. The method according to the preceding claim, wherein the wet chemical treatment is an etching process, further comprising:

- analysing surface property data of the substrate surface (41) provided by the at least second radiation (17) to determine an end of the etching process.