Claims

1. A method for cleaning at least a partial area of a substrate, said method comprising the steps of:
applying a liquid to at least a partial area of said substrate;
generating radicals in said liquid by means of UV radiation prior to applying the same to the substrate, wherein the generation of said radicals occurs directly before applying the liquid to the substrate, such that at least a portion of the radicals reaches the substrate.

2. The method of claim 1, wherein the liquid applied to the substrate forms a liquid film thereon, into which UV radiation is introduced, to maintain the activation of the radicals in said liquid film and/or to generate further radicals.

3. The method of claim 2, wherein said UV radiation, which is introduced into the liquid prior to applying the same to the substrate and into the liquid film on said substrate are at least partially emitted by the same radiation source.

4. The method of any one of the preceding claims, wherein the liquid containing the radicals is limited to selected surface areas of the substrate.

5. The method of any one of the preceding claims, wherein for generating the radicals in substance UV radiation having a wavelength in range of 140 nm to 280 nm, depending in on the liquid between 140 nm to 200 nm is used, wherein at least 50% of this UV radiation is absorbed in the liquid for generating radicals.

6. The method of claim 5, wherein at least 80% of the UV radiation having a wavelength in range of 140 nm to 280 nm, depending in on the liquid between 140 nm to 200 nm is absorbed.

7. The method of claim 5 or 6, wherein the absorption is achieved by matching the used liquid to the used wavelength in the above cited range.

8. The method of any one of the preceding claims, wherein the UV radiation is introduced into the liquid prior to applying the same while the liquid flows along a UV radiation source.

9. The method of claim 8, wherein the UV radiation is selected such that the molecular structure of the liquid is destroyed, in order to avoid undesired reactions with the substrate surface, and/or to enable a directly subsequent generation of radicals also by means of UV radiation.

10. The method of any one of the preceding claims, wherein as the liquid is at least one of the following is used: ozone water, hydrogen water, DI water, H_2O_2, CO_2-H_2O, DI water having O_2 gas dissolved therein, NH_4OH, acetic acid, citric acid, TMAH, HNO_3, HCl, H_2SO_4, H_3PO_4 or mixtures thereof.

11. The method of any one of the preceding claims, wherein said substrate is one of the following: a mask, in particular a photo mask for the manufacture of semiconductors, a semiconductor, in particular a Si-wafer, a Ge-wafer, a GaAs-wafer or an InP-wafer, a flat panel substrate, a multi layer ceramic substrate.

12. The method of any one of the preceding claims, wherein at least one of the following is at least partially removed from the substrate by the help of the radicals: organic contaminations as well as organic functional layers, such as positive resist, negative resist and ion implanted resist, carbon, hydrocarbons, embossing and imprint material, stress buffer and underfill materials, lacquers, dyes, bio materials and also bacteria.

13. The method of any one of the preceding claims, wherein the liquid is applied to local areas to be cleaned of the substrate.

14. A method for removing ions from at least partial areas of the surface of a substrate and near surface layers of said substrate, said method comprising the steps of:
applying a liquid which is heated above ambient temperature onto said substrate, in order to form a liquid film on at least a partial area of said substrate; and
introducing electromagnetic radiation into said liquid film such that at least a portion of said radiation reaches the surface of said substrate.

15. The method of claim 14, wherein the liquid is heated by means of electromagnetic radiation during the application thereof onto the substrate.

16. The method of claim 14 or 15, wherein the liquid is pre-heated before it is exposed to the electromagnetic radiation.

17. The method of any one of claims 14 to 16, wherein the liquid is heated to a temperature in the range between ambient temperature and the boiling point of the liquid.

18. The method of any one of claims 14 to 17, wherein the method is conducted under increased pressure.

19. The method of any one of claims 14 to 18, wherein as the liquid at least one of the following is used: ozone water, hydrogen water, DI water, H_2O_2, CO_2-H_2O, DI water having O_2 gas dissolved therein or mixtures thereof.

20. The method of any one of claims 14 to 19, wherein UV radiation is introduced into the liquid film.

21. The method of claim 20, wherein at least UV radiation having a wavelength above 190 nm is introduced into the liquid, and wherein at least 50% of said UV radiation reaches the interface between the surface of the substrate and the liquid film.

22. The method of claim 21, wherein at least 80% of the UV radiation having a wavelength above 190 nm reaches said interface.

23. The method of any one of claims 14 to 22, wherein IR radiation is introduced into the liquid film.

24. the method of claim 23, wherein at least 50% of the IR radiation reaches the interface between the surface of the substrate and the liquid film.

25. The method of claim 20 and 23, wherein the UV radiation and the IR radiation are introduced via the same radiation source.

26. The method of any one of claims 14 to 25, wherein at least a portion of the radiation generates radicals in the liquid film.

27. A method for changing the surface characteristics of a substrate having an at least partially hydrophobic substrate surface, such that at least a portion of said hydrophobic surface gets an hydrophilic surface characteristic, wherein said method comprises the following steps:
applying a liquid to at least the partial area of the surface, whose surface characteristic is to be changed; and
guiding UV radiation of a predetermined range of wavelength through said liquid

onto at least the partial area of the surface of said substrate, whose surface characteristic is to be changed.

28. The method of claim 27, wherein the predetermined wavelength range comprises UV radiation having a wavelength above 190 nm.

29. The method of claim 28, wherein at least 80% of the UV radiation within said predetermined wavelength range reach the surface of the substrate.

30. The method of one of claims 27 to 29, wherein as the liquid is at least one of the following is used: ozone water, hydrogen water, DI water, H_2O_2, CO_2-H_2O, DI water having O_2 gas dissolved therein, NH_4OH, organic acids, TMAH, HNO_3, HCl, H_2SO_4 or mixtures thereof.

31. The method of claim 30, wherein the liquid is DI water.

32. A method for treating a substrate in which at least two of the following methods are sequentially conducted: a method according to one of claims 27 to 31, a method according to one of claims 1 to 13 and a method according to one of claims 14 to 26.

33. The method of claim 32, wherein at least two of said methods are conducted sequentially in the above cited order.

34. The method of claim 32 or 33, wherein two of said methods are conducted in parallel.

35. The method according to any one of claims 32 to 34, wherein the methods are conducted in the same apparatus.

36. The method of claim 35, wherein the substrate remains in said apparatus between conducting said methods.

37. A method for treating a substrate, in which at least two of the following methods are conducted in parallel: a method according to one of claims 27 to 31, a method according to one of claims 1 to 13 and a method according to one of claims 14 to 26.

38. The method of claim 37, wherein all methods are conducted in parallel.

39. The method of claim 37, wherein two of said methods are conducted sequentially in the above cited order.

40. The method of claim 39, wherein the methods are conducted in the same apparatus.

41. The method of claim 40, wherein the substrate remains in the apparatus between conducting said methods.

42. An apparatus for treating substrates, said apparatus comprising:
a substrate holder for receiving the substrate;
a housing defining a flow chamber having an inlet and an outlet;
a first radiation source, which is arranged to emit radiation into said flow chamber, wherein said first radiation source is capable of emitting UV radiation; and
a unit for generating a relative movement between said substrate holder and said housing, said unit being capable to arrange said housing with respect to said substrate holder such that the outlet is directed towards the substrate holder such that a liquid exiting the outlet directly flows onto a substrate on the substrate holder.

43. The apparatus of claim 42, wherein the first radiation source is arranged such that it also emits radiation through said outlet out of the housing.

44. The apparatus of claim 42 or 43, wherein the first radiation source is at least partially arranged in said flow chamber.

45. The apparatus of any one of claims 42 to 44, wherein said housing comprises an outlet opening and said first radiation source is at least partially arranged in said outlet opening.

46. The apparatus of claim 45, wherein the first radiation source is substantially arranged in the middle of the outlet opening.

47. The apparatus of claim 45 or 46, wherein the outlet opening and the first radiation source have an extension in length which is greater or at least equal to an extension in width of the substrate to be cleaned.

48. The apparatus of any one of claims 42 to 47, wherein the first radiation source comprises a first lamp, which emits radiation in the UV range.

49. The apparatus of claim 48, wherein the first lamp emits radiation in the IR range.

50. The apparatus of claim 48 or 49, wherein the first radiation source comprises at least a second lamp emitting radiation in a primarily different wavelength range than the first lamp.

51. The apparatus of claim 48 to 50, wherein at least one cover is provided between the first and/or second lamp and the flow chamber, wherein the at least one cover is substantially transparent to UV radiation.

52. The apparatus of claim 51, wherein the at least one cover completely surrounds the first and/or second lamp in one plane.

53. The apparatus of any one of claims 48 to 52, wherein the first and/or second lamp is a rod lamp.

54. The apparatus of any one of claims 48 to 53, wherein the first lamp inter alia emits UV radiation in the wavelength range between 140 nm and 280 nm, depending in on the liquid between 140 nm to 200 nm.

55. The apparatus of claim 48, wherein the first lamp emits primarily UV radiation in the wavelength range between 140 nm and 280 nm, depending in on the liquid between 140 nm to 200 nm.

56. The apparatus of any one of claims 48 to 55, wherein the second lamp emits UV radiation in the wavelength range over 180nm.

57. The apparatus of any one of claims 50 to 56, wherein the second lamp emits IR radiation.

58. The apparatus of any one of claims 42 to 57, wherein at least one second radiation source is provided outside the flow chamber of the housing such that it emits radiation into an area adjacent to the outlet of the housing.

59. The apparatus of claim 58, wherein the second radiation source emits primarily in a different wavelength range than the first radiation source.

60. The apparatus of claim 58 or 59, wherein the second radiation source emits UV radiation in the wavelength range above 180nm.

61. The apparatus of any one of claims 58 to 60, wherein the second radiation source emits IR radiation.

62. The apparatus of any one of claims 58 to 61, wherein a control unit is provided, which is capable of individually and independently controlling the first and second radiation source.

CLAIMS:

1. A method for cleaning at least a partial area of a substrate, said method comprising the steps of:
applying a liquid to said at least partial area of said substrate by flowing liquid through a flow chamber having an outlet directed onto the substrate;
generating radicals in said liquid by means of UV radiation prior to applying the same to the substrate, wherein the UV radiation is introduced into the liquid while the liquid flows along a UV radiation source which is at least partially arranged in the outlet of the flow chamber, the UV radiation source emitting radiation into the liquid in said flow chamber and said outlet so that the generation of said radicals occurs directly before applying the liquid to the substrate, such that at least a portion of the radicals reaches the substrate.

2. The method of claim 1, wherein the liquid applied to the substrate forms a liquid film thereon, into which UV radiation is introduced, to at least one of maintain activation of the radicals in said liquid film and generate further radicals.

3. The method of claim 2, wherein said UV radiation, which is introduced into the liquid prior to applying the same to the substrate and into the liquid film on said substrate is at least partially emitted by a same radiation source

4. The method of any one of claims 1 to 3, wherein the liquid containing the radicals is limited to selected surface areas of the substrate.

5. The method of any one of claims 1 to 4, wherein for generating the radicals, the UV radiation has a wavelength in a range of 140 nm to 280 nm, wherein

at least 50% of the UV radiation in said range is absorbed in the liquid for generating radicals, and wherein a rate of absorption of the UV radiation is achieved by matching said liquid to said wavelength of the UV radiation in said range.

6. The method of claim 5, wherein at least 80% of the UV radiation in a range of 140 nm to 200 nm is absorbed.

7. The method of any one of claims 1 to 6, wherein the UV radiation is selected such that a molecular structure of the liquid is destroyed, in order to at least one of avoid undesired reactions with a surface of the substrate and enable a directly subsequent generation of radicals also by means of UV radiation.

8. The method of any one of claims 1 to 7, wherein at least one of the following is used as the liquid: ozone water, hydrogen water, DI water, H_2O_2, CO_2-H_2O, DI water having O_2 gas dissolved therein, NH_4OH, acetic acid, citric acid, TMAH, HNO_3, HCl, H_2SO_4, H_3PO_4 or mixtures thereof.

9. The method of any one of claims 1 to 8, wherein said substrate is one of the following: a mask, a semiconductor, a flat panel substrate and a multi layer ceramic substrate.

10. The method of any one of claims 1 to 8, wherein the substrate is a mask, said mask being a photo mask for semiconductor manufacturing.

11. The method of any one of claims 1 to 8, wherein the substrate is a semiconductor, said semiconductor being a Si wafer, a Ge wafer, a GaAs wafer or an InP wafer.

12. The method of any one of claims 1 to 11, wherein at least one of the following is at least partially removed from the substrate by the help of the radicals: organic contaminations and organic functional layers.

13. The method of claim 12, wherein the organic contaminations and the organic functional layers comprises at least one of positive resist, negative resist, ion implanted resist, carbon, hydrocarbons, embossing material, imprint material, stress buffer, underfill materials, lacquers, dyes, bio materials and bacteria

14. An apparatus (1) for treating a substrate (2), said apparatus (1) comprising:
a substrate holder (4) for receiving the substrate (2);
a housing (14) defining a flow chamber (22) having an inlet for a liquid and an outlet opening for the liquid;
a first radiation source (18) configured to emit UV radiation, the first radiation source (18) being at least partially arranged in said outlet opening to emit the UV radiation into said flow chamber (22) and said outlet opening; and
a unit for generating a relative movement between said substrate holder (4) and said housing (14), said unit being configured to arrange said housing (14) with respect to said substrate holder (4) such that the outlet opening is directed towards the substrate holder (4) such that a liquid exiting the outlet directly flows onto a substrate (2) on the substrate holder (4).

15. The apparatus of claim 14, wherein the first radiation source (18) is arranged such that it also emits the UV radiation through said outlet opening out of the housing (14).

16. The apparatus of claim 15, wherein the first radiation source (18) is arranged in a middle of the outlet opening.

17. The apparatus of claim 14 or 15, wherein the outlet opening and the first radiation source (18) have an extension in length which is equal to or greater than an extension in width of said substrate (2).

18. The apparatus of any one of claims 14 to 17, wherein the first radiation source (18) comprises a first lamp (30), which is adapted to at least emit radiation in the UV range.

19. The apparatus of claim 18, wherein the first lamp (30) emits the UV radiation in a wavelength range between 140 nm and 280 nm.

20. The apparatus of claim 19, wherein the first lamp (30) further emits radiation in the IR range.

21. The apparatus of any one of claims 18 to 20, wherein at least one cover (32) is provided between the flow chamber (22) and the first lamp (30), wherein the at least one cover is transparent to the UV radiation.

22. The apparatus of claim 21, wherein the at least one cover (32) surrounds the first lamp (30).

23. The apparatus of any one of claims 18 to 20, wherein the first radiation source (18) comprises at least one second lamp (30') which is adapted to emit radiation in a substantially different wavelength range than the first lamp (30).

24. The apparatus of claim 23, wherein the at least one second lamp (30') is adapted to emit UV radiation in the wavelength range over 180 nm.

25. The apparatus of claim 23 or 24, wherein the at least one second lamp (30') is adapted to emit IR radiation.

26. The apparatus of any one of claims 23 to 25, wherein at least one cover (32) is provided between the flow chamber (22) and at least one of the first and the at least one second lamp (30, 30'), wherein the at least one cover (32) is transparent to the UV radiation.

27. The apparatus of claim 26, wherein the at least one cover (32) surrounds the at least one of the first and the at least one second lamp (30, 30').

28. The apparatus of any one of claims 14 to 27, wherein at least one second radiation source (40) is provided, which is arranged outside the flow chamber (22) of the housing (14) such that said at least one second radiation source (40) emits radiation into an area adjacent to the outlet opening of the housing (14).

29. The apparatus of claim 28, wherein the at least one second radiation source (40) is adapted to emit radiation primarily in a different wavelength range than the first radiation source (18).

30. The apparatus of claim 29, wherein the at least one second radiation source emits UV radiation in a wavelength range above 180 nm.

31. The apparatus of claim 28 or 29, wherein the second radiation source emits IR radiation.

32. The apparatus of any one of claims 28 to 31, wherein a control unit is provided, which is capable of individually and independently controlling the first and second radiation sources (18, 40).