

CLAIMS

1. A method for cleaning semiconductor substrate without damaging patterned structure on said substrate using ultra/mega sonic device, comprising:

applying liquid into a space between a substrate and an ultra/mega sonic device;

setting an ultra/mega sonic power supply at frequency f_1 and power P_1 to drive said ultra/mega sonic device;

before bubble cavitation in said liquid damaging patterned structure on said substrate, setting said ultra/mega sonic power supply at frequency f_2 and power P_2 to drive said ultra/mega sonic device;

after temperature inside bubble cooling down to a set temperature, setting said ultra/mega sonic power supply at frequency f_1 and power P_1 again;

repeating above steps till said substrate being cleaned.

2. The method of claim 1, wherein said bubble cavitation damaging patterned structure on said substrate is caused by micro jet generated by bubble implosion.

3. The method of claim 1, wherein time interval between setting said power supply at frequency f_1 and power P_1 and setting said ultra/mega sonic power supply at frequency f_2 and power P_2 is shorter than 2,000 times of cycle period of waveform at frequency f_1 .

4. The method of claim 1, wherein time interval between setting said power supply at frequency f_1 and power P_1 and setting said ultra/mega sonic power supply at frequency f_2 and power P_2 is shorter than $((T_i - T_0 - \Delta T)/(\Delta T - \delta T) + 1)/f_1$, where T_i is gas and vapor temperature inside said bubble when said bubble implosion, T_0 temperature of said liquid, ΔT temperature increase after one time of compression of said bubbler, δT temperature decrease after one time of expansion of said bubbler.

5. The method of claim 1, wherein said bubble cavitation damaging patterned structure on said substrate is caused by bubble size growing bigger than space in patterned structure.

6. The method of claim 1, wherein said set temperature is near temperature of said liquid.

7. The method of claim 1, wherein said power value P_2 is set as zero.

8. The method of claim 1, wherein said frequency f_1 is equal to said frequency f_2 , and said power value P_2 is smaller than said power value P_1 .

9. The method of claim 1, wherein said frequency f_1 is higher than said frequency f_2 , and said power value P_2 is smaller than said power value P_1 .

10. The method of claim 1, wherein said frequency f_1 is lower than said frequency f_2 , and said power value P_1 is equal to said power value P_2 .

11. The method of claim 1, wherein said frequency f_1 is lower than said frequency f_2 , and said power value P_1 is larger than said power value P_2 .

12. The method of claim 1, wherein said frequency f_1 is lower than said frequency f_2 , and said power value P_1 is smaller than said power value P_2 .

13. The method of claim 1, wherein said ultra/mega sonic power supply outputs power P_1 with increased amplitude.

14. The method of claim 1, wherein said ultra/mega sonic power supply outputs power P_1 with decreased amplitude.

15. The method of claim 1, wherein said ultra/mega sonic power supply outputs power P_1 with increased amplitude at beginning and with decreased amplitude at later.

16. The method of claim 1, wherein said ultra/mega sonic power supply outputs power P_1 with decreased amplitude at first and with increased amplitude at later.

17. The method of claim 1, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_1 first and at frequency f_3 later, where f_3 is smaller than f_1 .

18. The method of claim 1, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_3 first and at frequency f_1 later, where f_3 is smaller than f_1 .

19. The method of claim 1, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_3 first, at frequency f_1 later and at frequency f_3 last, where f_3 is smaller than f_1 .

20. The method of claim 1, wherein said ultra/mega sonic power supply outputs waveform at frequency f_1 first, at frequency f_3 later and at frequency f_1 last, where f_3 is smaller than f_1 .

21. The method of claim 1, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_1 first, at frequency f_3 later and at frequency f_4 at last, where f_4 is smaller than f_3 , and f_3 is smaller than f_1 .

22. The method of claim 1, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_4 first, at frequency f_3 later and at frequency f_1 at last, where f_4 is smaller than f_3 , and f_3 is smaller than f_1 .

23. The method of claim 1, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_1 first, at frequency f_4 later and at frequency f_3 at last, where f_4 is smaller than f_3 , and f_3 is smaller than f_1 .

24. The method of claim 1, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_3 first, at frequency f_4 later and at frequency f_1 at last, where f_4 is smaller than f_3 , and f_3 is smaller than f_1 .

25. The method of claim 1, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_3 first, at frequency f_1 later and at frequency f_4 at last, where f_4 is smaller than f_3 , and f_3 is smaller than f_1 .

26. The method of claim 1, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_4 first, at frequency f_1 later and at frequency f_3 at last, where f_4 is smaller than f_3 , and f_3 is smaller than f_1 .

27. The method of claim 1, wherein said frequency f_2 is equal to zero, said power value P_2 is a positive value.

28. The method of claim 1, wherein said frequency f_2 is equal to zero, said power value P_2 is a negative value.

29. The method of claim 1, wherein said frequency f_2 is equal to f_1 , and phase of f_2 is set as reverse to phase of f_1

30. The method of claim 1, wherein said frequency f_2 is different from f_1 , and phase of f_2 is set as reverse to phase of f_1

31. Apparatus for cleaning semiconductor substrate using ultra/mega sonic device, comprising:

- a chuck holding a semiconductor substrate;
- an ultra/mega sonic device being positioned adjacent to said semiconductor substrate;
- at least one nozzle injecting chemical liquid on said semiconductor substrate and a gap between said semiconductor substrate and said ultra/mega sonic device; and
- an ultra/mega sonic power supply;

wherein the ultra/mega sonic power supply is set at frequency f_1 and power P_1 to drive said ultra/mega sonic device; at frequency f_2 and power P_2 to drive said ultra/mega sonic device before bubble cavitation in said liquid damaging patterned structure on said substrate; and, after temperature inside bubble is cooled down to a set temperature, said ultra/mega sonic power supply is set at the frequency f_1 and power P_1 again; and wherein said ultra/mega sonic power supply is arranged to repeat the above till said substrate is cleaned.

32. The apparatus of claim 31, wherein said bubble cavitation damaging patterned structure on said substrate is caused by micro jet generated by bubble implosion.

33. The apparatus of claim 31, wherein time interval between setting said power supply at frequency f_1 and power P_1 and setting said ultra/mega sonic power supply at frequency f_2 and power P_2 is shorter than 2,000 times of cycle period of waveform at frequency f_1

34. The apparatus of claim 31, wherein time interval between setting said power supply at frequency f_1 and power P_1 and setting said ultra/mega sonic power supply at frequency f_2 and power P_2 is shorter than $((T_i - T_0 - \Delta T)/(\Delta T - \delta T) + 1)/f_1$, where T_i is gas and vapor temperature inside said bubble when said bubble implosion, T_0 temperature of said liquid, ΔT temperature increase after one time of compression of said bubbler, δT temperature decrease after one time of expansion of said bubbler.

35. The apparatus of claim 31, wherein said bubble cavitation damaging patterned structure on said substrate is caused by bubble size growing bigger than space in patterned structure.

36. The apparatus of claim 31, wherein said set temperature is near temperature of said liquid.

37. The apparatus of claim 31, wherein said power value P_2 is set as zero.

38. The apparatus of claim 31, wherein said frequency f_1 is equal to said frequency f_2 , and said power value P_2 is smaller than said power value P_1 .

39. The apparatus of claim 31, wherein said frequency f_1 is higher than said frequency f_2 , and said power value P_2 is smaller than said power value P_1 .

40. The apparatus of claim 31, wherein said frequency f_1 is lower than said frequency f_2 , and said power value P_1 is equal to said power value P_2 .

41. The apparatus of claim 31, wherein said frequency f_1 is lower than said frequency f_2 , and said power value P_1 is larger than said power value P_2 .

42. The apparatus of claim 31, wherein said frequency f_1 is lower than said frequency f_2 , and said power value P_1 is smaller than said power value P_2 .

43. The apparatus of claim 31, wherein said ultra/mega sonic power supply outputs power P_1 with increased amplitude.

44. The apparatus of claim 31, wherein said ultra/mega sonic power supply outputs power P_1 with decreased amplitude.

45. The apparatus of claim 31, wherein said ultra/mega sonic power supply outputs power P_1 with increased amplitude at beginning and with decreased amplitude at later.

46. The apparatus of claim 31, wherein said ultra/mega sonic power supply outputs power P_1 with decreased amplitude at first and with increased amplitude at later.

47. The apparatus of claim 31, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_1 first and at frequency f_3 later, where f_3 is smaller than f_1 .

48. The apparatus of claim 31, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_3 first and at frequency f_1 later, where f_3 is smaller than f_1 .

49. The apparatus of claim 31, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_3 first, at frequency f_1 later and at frequency f_3 last, where f_3 is smaller than f_1 .

50. The apparatus of claim 31, wherein said ultra/mega sonic power supply outputs waveform at frequency f_1 first, at frequency f_3 later and at frequency f_1 last, where f_3 is smaller than f_1 .

51. The apparatus of claim 31, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_1 first, at frequency f_3 later and at frequency f_4 at last, where f_4 is smaller than f_3 , and f_3 is smaller than f_1 .

52. The apparatus of claim 31, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_4 first, at frequency f_3 later and at frequency f_1 at last, where f_4 is smaller than f_3 , and f_3 is smaller than f_1 .

53. The apparatus of claim 31, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_1 first, at frequency f_4 later and at frequency f_3 at last, where f_4 is smaller than f_3 , and f_3 is smaller than f_1 .

54. The apparatus of claim 31, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_3 first, at frequency f_4 later and at frequency f_1 at last, where f_4 is smaller than f_3 , and f_3 is smaller than f_1 .

55. The apparatus of claim 31, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_3 first, at frequency f_1 later and at frequency f_4 at last, where f_4 is smaller than f_3 , and f_3 is smaller than f_1 .

56. The apparatus of claim 31, wherein said ultra/mega sonic power supply outputs power P_1 at frequency f_4 first, at frequency f_1 later and at frequency f_3 at last, where f_4 is smaller than f_3 , and f_3 is smaller than f_1 .

57. The apparatus of claim 31, wherein said frequency f_2 is equal to zero, said power value P_2 is a positive value.

58. The apparatus of claim 31, wherein said frequency f_2 is equal to zero, said power value P_2 is a negative value.

59. The apparatus of claim 31, wherein said frequency f_2 is equal to f_1 , and phase of f_2 is set as reverse to phase of f_1 .

60. The apparatus of claim 31, wherein said frequency f_2 is different from f_1 , and phase of f_2 is set as reverse to phase of f_1 .

61. Apparatus for cleaning semiconductor substrate using ultra/mega sonic device, comprising:

a cassette holding at least one semiconductor substrate;

a tank holding said cassette;

an ultra/mega sonic device being attached to outside wall of said tank;

at least one inlet for filling chemical liquid into said tank to immerse said semiconductor substrate; and

an ultra/mega sonic power supply; wherein the ultra/mega sonic power supply is set at frequency f_1 and power P_1 to drive said ultra/mega sonic device; at frequency f_2 and power P_2 to drive ultra/mega sonic device before bubble cavitation in said liquid damaging patterned structure on the substrate; and after temperature inside bubble is cooled down to a set temperature, said ultra/mega sonic power supply is set at the frequency f_1 and power P_1 again; and wherein said ultra/mega sonic power supply is arranged to repeat the above till said substrate is cleaned.

62. The apparatus of claim 61, wherein said power value P_2 is set as zero.

63. Apparatus for cleaning semiconductor substrate using ultra/mega sonic device, comprising:

a chuck holding a semiconductor substrate;

an ultra/mega sonic device coupled with a nozzle being positioned adjacent to said semiconductor substrate, said nozzle injecting chemical liquid on said semiconductor substrate; and

an ultra/mega sonic power supply; wherein the ultra/mega sonic power supply is set at frequency f_1 and power P_1 to drive said ultra/mega sonic device; at frequency f_2 and power P_2 to drive ultra/mega sonic device before bubble cavitation in said liquid damaging patterned structure on the substrate; and after temperature inside bubble is cooled down to a set temperature, said ultra/mega sonic power supply is set at the frequency f_1 and power P_1 again; and wherein said ultra/mega sonic power supply is arranged to repeat the above till said substrate is cleaned.

64. The apparatus of claim 63, wherein said power value P_2 is set as zero.