

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 .