SUMMARY OF INVENTION

[Para 13] The invention relates, in an embodiment, to a method for processing a substrate in a capacitively-coupled plasma processing system, which has a plasma processing chamber and at least an upper electrode and a lower electrode. The substrate is disposed on the lower electrode during plasma processing. The method includes providing at least a first RF signal to the lower electrode. The first RF signal has a first RF frequency. The first RF signal couples with a plasma in the plasma processing chamber, thereby inducing an induced RF signal on the upper electrode. The method also includes rectifying the induced RF signal to generate a rectified RF signal such that the rectified RF signal is more ~~positively~~ biased than ~~negatively~~ biased. The method further includes processing the substrate while the rectified RF signal is provided to the upper electrode.

[Para 14] The above summary relates to only one of the many embodiments of the invention disclosed herein and is not intended to limit the scope of the invention, which is set forth in the claims herein. These and other features of the present invention will be described in more detail below in the detailed description of the invention and in conjunction with the following figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[Para 15] The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

[Para 16] FIG. 1 shows a prior art multi-frequency capacitively-coupled plasma processing system representing the plasma processing system typically employed to process substrates.

[Para 17] FIG. 2 shows a prior art implementation whereby one or more high frequency RF signals are provided to upper electrode in order to provide additional control over the generation of ions within chamber.

[Para 18] FIG. 3a shows an implementation wherein a rectifier circuit is employed to rectify the induced voltage that exists on upper electrode during plasma processing.

[Para 19] FIG. 3b shows an example RF signal.

CLAIMS

What is claimed is:

1. A method for processing a substrate in a capacitively-coupled plasma processing system, said capacitively-coupled plasma processing system having a plasma processing chamber and at least an upper electrode and a lower electrode, said substrate being disposed on said lower electrode during plasma processing, comprising:

providing at least a first RF signal to said lower electrode, said first RF signal having a first RF frequency, said first RF signal coupling with a plasma in said plasma processing chamber, thereby inducing an induced RF signal on said upper electrode;

rectifying said induced RF signal to generate a rectified RF signal such that said rectified RF signal is more ~~positively~~ biased than ~~negatively~~ biased; and

processing said substrate while said rectified RF signal is provided to said upper electrode.

2. The method of claim 1 wherein said rectifying includes removing ~~negative~~ components of said induced RF signal.

3. The method of claim 1 further comprising providing a second RF signal to said lower electrode, said second RF signal having a second RF frequency different from said first RF signal.

4. The method of claim 3 wherein said second RF frequency is one of 2 MHz, 27 MHz and 60 MHz.

5. The method of claim 1 wherein said rectifying further including amplifying an amplitude of said induced RF signal to generate said rectified RF signal.

6. The method of claim 1 wherein said capacitively-coupled plasma processing system represents a multi-frequency capacitively-coupled plasma processing system.

7. The method of claim 1 wherein said rectifying said induced RF signal to generate said rectified RF signal is performed using a rectifying arrangement.

8. The method of claim 7 wherein said rectifying arrangement includes a power MOSFET.

9. A capacitively-coupled plasma processing system having a plasma processing chamber for processing a substrate, comprising:

at least an upper electrode and a lower electrode for processing said substrate, said substrate being disposed on said lower electrode during plasma processing;

means for providing at least a first RF signal to said lower electrode, said first RF signal having a first RF frequency, said first RF signal coupling with a plasma in said plasma processing chamber, thereby inducing an induced RF signal on said upper electrode;

means for rectifying said induced RF signal to generate a rectified RF signal such that said rectified RF signal is more ~~positively~~ biased than ~~negatively~~ biased, wherein said substrate is configured to be processed while said rectified RF signal is provided to said upper electrode.

10. The capacitively-coupled plasma processing system of claim 9 wherein said rectifying includes removing ~~negative~~ components of said induced RF signal.

11. The capacitively-coupled plasma processing system of claim 9 further comprising means for providing a second RF signal to said lower electrode, said second RF signal having a second RF frequency different from said first RF signal.

12. The capacitively-coupled plasma processing system of claim 11 wherein said second RF frequency is one of 2 MHz, 27 MHz and 60 MHz.

13. The capacitively-coupled plasma processing system of claim 9 wherein said rectifying further including amplifying an amplitude of said induced RF signal to generate said rectified RF signal.

14. The capacitively-coupled plasma processing system of claim 9 wherein said capacitively-coupled plasma processing system represents a multi-frequency capacitively-coupled plasma processing system.

15. The capacitively-coupled plasma processing system of claim 9 wherein said rectifying said induced RF signal to generate said rectified RF signal is performed using a rectifying arrangement.

16. The capacitively-coupled plasma processing system of claim 15 wherein said rectifying arrangement includes a power MOSFET.

17. A capacitively-coupled plasma processing system having a plasma processing chamber for processing a substrate, comprising:

at least an upper electrode and a lower electrode for processing said substrate, said substrate being disposed on said lower electrode during plasma processing;

means for providing a plurality of RF signals to said lower electrode, a first RF signal of said plurality of RF signals having a first RF frequency, said first RF signal coupling with a plasma in said plasma processing chamber, thereby inducing an induced RF signal on said upper electrode;

a rectifying arrangement coupled to said induced RF signal to generate a rectified RF signal such that said rectified RF signal is more ~~positively~~ biased than ~~negatively~~ biased; and

means for processing said substrate while said rectified RF signal is provided to said upper electrode.

18. The capacitively-coupled plasma processing system of claim 17 wherein said rectifying arrangement includes circuitry configured to remove ~~negative~~ components of said induced RF signal.

19. The capacitively-coupled plasma processing system of claim 17 wherein said rectifying arrangement further includes circuitry configured to amplify an amplitude of said induced RF signal to generate said rectified RF signal.

SUMMARY OF INVENTION

[Para 13] The invention relates, in an embodiment, to a method for processing a substrate in a capacitively-coupled plasma processing system, which has a plasma processing chamber and at least an upper electrode and a lower electrode. The substrate is disposed on the lower electrode during plasma processing. The method includes providing at least a first RF signal to the lower electrode. The first RF signal has a first RF frequency. The first RF signal couples with a plasma in the plasma processing chamber, thereby inducing an induced RF signal on the upper electrode. The method also includes rectifying the induced RF signal to generate a rectified RF signal such that the rectified RF signal is more negatively biased than positively biased. The method further includes processing the substrate while the rectified RF signal is provided to the upper electrode.

[Para 14] The above summary relates to only one of the many embodiments of the invention disclosed herein and is not intended to limit the scope of the invention, which is set forth in the claims herein. These and other features of the present invention will be described in more detail below in the detailed description of the invention and in conjunction with the following figures.

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[Para 15] The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

[Para 16] FIG. 1 shows a prior art multi-frequency capacitively-coupled plasma processing system representing the plasma processing system typically employed to process substrates.

[Para 17] FIG. 2 shows a prior art implementation whereby one or more high frequency RF signals are provided to upper electrode in order to provide additional control over the generation of ions within chamber.

[Para 18] FIG. 3a shows an implementation wherein a rectifier circuit is employed to rectify the induced voltage that exists on upper electrode during plasma processing.

[Para 19] FIG. 3b shows an example RF signal.

CLAIMS

What is claimed is:

1. A method for processing a substrate in a capacitively-coupled plasma processing system, said capacitively-coupled plasma processing system having a plasma processing chamber and at least an upper electrode and a lower electrode, said substrate being disposed on said lower electrode during plasma processing, comprising:

providing at least a first RF signal to said lower electrode, said first RF signal having a first RF frequency, said first RF signal coupling with a plasma in said plasma processing chamber, thereby inducing an induced RF signal on said upper electrode;

rectifying said induced RF signal to generate a rectified RF signal such that said rectified RF signal is more negatively biased than positively biased; and

processing said substrate while said rectified RF signal is provided to said upper electrode.

2. The method of claim 1 wherein said rectifying includes removing positive components of said induced RF signal.

3. The method of claim 1 further comprising providing a second RF signal to said lower electrode, said second RF signal having a second RF frequency different from said first RF signal.

4. The method of claim 3 wherein said second RF frequency is one of 2 MHz, 27 MHz and 60 MHz.

5. The method of claim 1 wherein said rectifying further including amplifying an amplitude of said induced RF signal to generate said rectified RF signal.

6. The method of claim 1 wherein said capacitively-coupled plasma processing system represents a multi-frequency capacitively-coupled plasma processing system.

7. The method of claim 1 wherein said rectifying said induced RF signal to generate said rectified RF signal is performed using a rectifying arrangement.

8. The method of claim 7 wherein said rectifying arrangement includes a power MOSFET.

9. A capacitively-coupled plasma processing system having a plasma processing chamber for processing a substrate, comprising:

at least an upper electrode and a lower electrode for processing said substrate, said substrate being disposed on said lower electrode during plasma processing;

means for providing at least a first RF signal to said lower electrode, said first RF signal having a first RF frequency, said first RF signal coupling with a plasma in said plasma processing chamber, thereby inducing an induced RF signal on said upper electrode;

means for rectifying said induced RF signal to generate a rectified RF signal such that said rectified RF signal is more negatively biased than positively biased, wherein said substrate is configured to be processed while said rectified RF signal is provided to said upper electrode.

10. The capacitively-coupled plasma processing system of claim 9 wherein said rectifying includes removing positive components of said induced RF signal.

11. The capacitively-coupled plasma processing system of claim 9 further comprising means for providing a second RF signal to said lower electrode, said second RF signal having a second RF frequency different from said first RF signal.

12. The capacitively-coupled plasma processing system of claim 11 wherein said second RF frequency is one of 2 MHz, 27 MHz and 60 MHz.

13. The capacitively-coupled plasma processing system of claim 9 wherein said rectifying further including amplifying an amplitude of said induced RF signal to generate said rectified RF signal.

14. The capacitively-coupled plasma processing system of claim 9 wherein said capacitively-coupled plasma processing system represents a multi-frequency capacitively-coupled plasma processing system.

15. The capacitively-coupled plasma processing system of claim 9 wherein said rectifying said induced RF signal to generate said rectified RF signal is performed using a rectifying arrangement.

16. The capacitively-coupled plasma processing system of claim 15 wherein said rectifying arrangement includes a power MOSFET.

17. A capacitively-coupled plasma processing system having a plasma processing chamber for processing a substrate, comprising:

at least an upper electrode and a lower electrode for processing said substrate, said substrate being disposed on said lower electrode during plasma processing;

means for providing a plurality of RF signals to said lower electrode, a first RF signal of said plurality of RF signals having a first RF frequency, said first RF signal coupling with a plasma in said plasma processing chamber, thereby inducing an induced RF signal on said upper electrode;

a rectifying arrangement coupled to said induced RF signal to generate a rectified RF signal such that said rectified RF signal is more negatively biased than positively biased; and

means for processing said substrate while said rectified RF signal is provided to said upper electrode.

18. The capacitively-coupled plasma processing system of claim 17 wherein said rectifying arrangement includes circuitry configured to remove positive components of said induced RF signal.

19. The capacitively-coupled plasma processing system of claim 17 wherein said rectifying arrangement further includes circuitry configured to amplify an amplitude of said induced RF signal to generate said rectified RF signal.