Claims

1. A method of processing a substrate to form a carbon hardmask comprising at least two carbon hardmask layers, comprising:

depositing a first carbon hardmask layer over a film stack formed on the substrate, wherein the substrate is positioned on an electrostatic chuck disposed in a process chamber;

implanting ions into the carbon hardmask layer, wherein depositing the carbon hardmask layer and implanting ions into the carbon hardmask are performed in the same process chamber; and

without the substrate leaving the process chamber, repeating depositing the one or more carbon hardmask layers and implanting ions into the carbon hardmask layer in a cyclic fashion until a pre-determined thickness of the carbon hardmask is reached.

2. The method of claim 1, wherein depositing the carbon hardmask is performed by applying a first RF power having a first power level to the electrostatic chuck via a first electrode disposed in the electrostatic chuck.

3. The method of claim 2, wherein the first RF power is in a range of about 1 Kilowatts to about 10 Kilowatts at a frequency of about 0.4 MHz to about 300 MHz.

4. The method of claim 2, wherein implanting ions into the carbon hardmask further comprising:

after depositing the carbon hardmask over the film stack, discontinuing a flow of a hydrocarbon-containing gas for forming the carbon hardmask; and

reducing the first RF power from the first power level to a second power level that is sufficient to sustain plasma in the process chamber.

5. The method of claim 1, wherein implanting ions into the carbon hardmask is performed by applying a DC bias voltage to the electrostatic chuck via a second electrode disposed in the electrostatic chuck.

6. The method of claim 5, wherein the DC bias voltage is in a range of about 2 Kilovolts to about 15 Kilovolts.

7. The method of claim 5, wherein the DC bias voltage is provided at a pulse frequency of 10 Hz to about 10 kHz with a pulse width of about 5 microseconds to about 30 milliseconds.

8. The method of claim 1, wherein implanting ions into the carbon hardmask is performed by applying a second RF power to the electrostatic chuck via a third electrode disposed in the electrostatic chuck.

9. The method of claim 8, wherein the second RF power is in a range of about 1 Kilowatts to about 10 Kilowatts at a frequency of about 0.4 MHz to about 300 MHz.

10. The method of claim 9, wherein the second RF power is pulsed with a duty cycle in a range from about 10 % to about 80 %.

11. A method of processing a substrate, comprising:

depositing a carbon hardmask over a film stack formed on the substrate, wherein the substrate is positioned on an electrostatic chuck disposed in a process chamber;

implanting ions into the carbon hardmask, wherein depositing the carbon hardmask and implanting ions into the carbon hardmask are performed in the same process chamber; repeating depositing the carbon hardmask and implanting ions into the carbon hardmask in a cyclic fashion until a pre-determined thickness of the carbon hardmask is reached; and

after depositing the carbon hardmask over the film stack, discontinuing a flow of a hydrocarbon-containing gas for forming the carbon hardmask; and

reducing the first RF power from the first power level to a second power level that is sufficient to sustain plasma in the process chamber.

12. The method of claim 11, wherein depositing the carbon hardmask is performed by applying a first RF power having a first power level to the electrostatic chuck via a first electrode disposed in the electrostatic chuck.

13. The method of claim 12, wherein the first RF power is in a range of about 1 Kilowatts to about 10 Kilowatts at a frequency of about 0.4 MHz to about 300 MHz.

14. The method of claim 11, wherein implanting ions into the carbon hardmask is performed by applying a DC bias voltage to the electrostatic chuck via a second electrode disposed in the electrostatic chuck.

15. The method of claim 14, wherein the DC bias voltage is in a range of about 2 Kilovolts to about 15 Kilovolts.

16. The method of claim 14, wherein the DC bias voltage is provided at a pulse frequency of 10 Hz to about 10 kHz with a pulse width of about 5 microseconds to about 30 milliseconds.

17. The method of claim 11, wherein implanting ions into the carbon hardmask is performed by applying a second RF power to the electrostatic chuck via a third electrode disposed in the electrostatic chuck.

18. The method of claim 17, wherein the second RF power is in a range of about 1 Kilowatts to about 10 Kilowatts at a frequency of about 0.4 MHz to about 300 MHz.

19. The method of claim 18, wherein the second RF power is pulsed with a duty cycle in a range from about 10 % to about 80 %.