Claims

1. A method of forming an amorphous carbon film, comprising:

depositing an amorphous carbon film on an underlayer positioned on a susceptor in a first processing region;

forming a doped amorphous carbon film by implanting a dopant or inert species into the amorphous carbon film in a second processing region, wherein the dopant or inert species is selected from carbon, boron, nitrogen, silicon, phosphorous, argon, helium, neon, krypton, xenon or combinations thereof, wherein a target temperature during implanting the dopant or inert species is between about -100 degrees Celsius and about 0 degrees Celsius;

patterning the doped amorphous carbon film; and

etching the underlayer.

2. The method of claim 1, wherein the underlayer comprises a single layer or a dielectric stack.

3. The method of claim 1, wherein depositing the amorphous carbon film on the underlayer comprises:

flowing a hydrocarbon-containing gas mixture into the first processing region; and

generating an RF plasma in the first processing region to form the amorphous carbon film on the underlayer.

4. The method of claim 3, wherein a distance between a gas distribution showerhead positioned in the first processing region and the susceptor is between about 200 mils and about 1,000 mils.

5. The method of claim 4, wherein a pressure within the first processing region is between about 4 Torr and about 8 Torr.

6. The method of claim 1, wherein an implant energy utilized to energize the dopant or inert species is between about 5 keV and about 60 keV.

7. The method of claim 6, wherein an ion dosage is between about 5 x 10^{13} ions/cm^2 and about 5 x 10^{16} ions/cm^2.

8. The method of claim 6, wherein the dopant is carbon.

9. A method of forming an amorphous carbon film, comprising:

depositing an amorphous carbon film on an underlayer positioned on a susceptor in a first processing region;

forming a doped amorphous carbon film by implanting a dopant or inert species into the amorphous carbon film in a second processing region, wherein the dopant or inert species is selected from carbon, boron, nitrogen, silicon, phosphorous, argon, helium, neon, krypton, xenon or combinations thereof, wherein a target temperature during implanting the dopant or inert species is between about -100 degrees Celsius and about 0 degrees Celsius;

patterning the doped amorphous carbon film; and

etching the underlayer, wherein the doped amorphous carbon film has a refractive index at 633 nm of from about 2.1 to about 2.2.

10. The method of claim 9, wherein the doped amorphous carbon film has a k-value at 633 nm of less than 1.0.

11. The method of claim 9, wherein the doped amorphous carbon film has a Young's modulus (GPa) of from about 70 to about 200 GPa.

12. The method of claim 11, wherein the doped amorphous carbon film has a hardness (GPa) of from about 14 GPa to about 22 GPa.

13. The method of claim 12, wherein the doped amorphous carbon film has a stress (MPa) of from about -600 MPa to about 0 MPa.

14. The method of claim 13, wherein the doped amorphous carbon film has a density (g/cc) from about 1.95 g/cc to about 2.1 g/cc.

15. The method of claim 14, wherein the doped amorphous carbon film has a thickness between about 10 Å and about 50,000 Å.

16. A method of forming an amorphous carbon film, comprising:

depositing an amorphous carbon film on an underlayer positioned on a susceptor in a first processing region;

forming a doped amorphous carbon film by implanting a carbon dopant into the amorphous carbon film in a second processing region, wherein a target temperature during implanting the carbon dopant is between about -100 degrees Celsius and about 0 degrees Celsius;

patterning the doped amorphous carbon film; and

etching the underlayer, wherein the doped amorphous carbon film has a hardness (GPa) of from about 14 GPa to about 22 GPa.

17. The method of claim 16, wherein the doped amorphous carbon film has a refractive index at 633 nm of from about 2.1 to about 2.2.

18. The method of claim 17, wherein the doped amorphous carbon film has a k-value at 633 nm of less than 1.0.

19. The method of claim 16, wherein the doped amorphous carbon film has a Young’s modulus (GPa) of from about 70 to about 200 GPa.

20. The method of claim 19, wherein the doped amorphous carbon film has:

a stress (MPa) of from about -600 MPa to about 0 MPa;
a density (g/cc) from about 1.95 g/cc to about 2.1 g/cc; and
a thickness between about 10 Å and about 50,000 Å.