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 an inert species into the amorphous carbon film in a second processing region, wherein the dopant or the inert species is selected from beryllium, germanium, or combinations thereof, wherein a target temperature during implanting the dopant or the inert species is between -100 degrees Celsius and 550 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 200 mils and 1,000 mils.

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

6. The method of claim 1, wherein an implant energy utilized to energize the dopant or the inert species is between 5 keV and 300 keV.

7. The method of claim 6, wherein an ion dosage is between 1 x 10^{13} ions/cm^2 and 5 x 10^{16} ions/cm^2.

8. The method of claim 6 wherein implanting the dopant or the inert species into the patterned amorphous carbon film is performed at an angle between 1 degree and 80 degrees.

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 an inert species into the amorphous carbon film in a second processing region, wherein the dopant or the inert species is selected from beryllium, germanium, or combinations thereof, wherein a target temperature during implanting the dopant or the inert species is between -100 degrees Celsius and 550 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 2.1 to 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 70 to 200 GPa.

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

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

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

15. The method of claim 14, wherein the doped amorphous carbon film has a thickness between 10 Å and 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 the dopant is selected from beryllium, germanium, or combinations thereof, wherein a target temperature during implanting the carbon dopant is between -100 degrees Celsius and 550 degrees Celsius;

patterning the doped amorphous carbon film; and

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

17. The method of claim 16, wherein the doped amorphous carbon film has a refractive index at 633 nm of 2.1 to 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 70 to 200 GPa.

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

a stress (MPa) of -600 MPa to 0 MPa;

a density (g/cc) from 1.95 g/cc to 2.1 g/cc; and

a thickness between 10 Å and 50,000 Å.