CLAIMS

1. A method for forming a dielectric barrier layer comprising:

exposing a substrate having a copper surface thereon to a dopant gas to provide a layer of dopant on the copper surface, the dopant gas comprising at least one species with atoms of a group III or group V element;

depositing a doped dielectric layer by exposing the substrate to a silicon precursor, the dopant gas and a plasma to form a doped dielectric layer; and annealing the doped dielectric layer to form a dielectric barrier layer.

2. The method of claim 1, wherein the dopant gas is flowed at a flow rate up to about 500 sccm.

3. The method of claim 1, wherein the dopant gas comprises boron atoms.

4. The method of claim 3, wherein the dopant gas consists essentially of diborane.

5. The method of claim 1, wherein the dopant gas comprises phosphorous atoms.

6. The method of claim 5, wherein the dopant gas consists essentially of phosphine.

7. The method of claim 1, wherein the dopant gas comprises nitrogen atoms.

8. The method of claim 7, wherein the dopant gas comprises one or more of nitrogen (N_2), ammonia, NO_2, and N_2O.

9. The method of claim 1, wherein depositing the doped dielectric layer is performed by a plasma-enhanced chemical vapor deposition process utilizing a silicon precursor comprising carbon and a plasma gas comprising oxygen.

10. The method of claim 9, wherein the doped dielectric layer comprises a doped SiOC layer.

11. The method of claim 1, wherein annealing the doped dielectric layer is performed in an atmosphere comprising N_2.

12. The method of claim 1, wherein the doped dielectric layer is annealed at a temperature of less than about 500 °C.

13. The method of claim 1, wherein the doped dielectric layer is annealed for a period in a range of about 1 min to about 120 min.

14. The method of claim 1, further comprising exposing the dielectric barrier layer to a treatment plasma to improve at least one of elasticity and hardness.

15. The method of claim 14, wherein the treatment plasma comprises ammonia.

16. The method of claim 14, wherein the treatment plasma has a power in a range of about 250 W to about 500 W and the dielectric barrier layer is exposed for less than or equal to about 20 s.

17. A method for forming a dielectric barrier layer comprising:

depositing a dielectric layer on a substrate having a copper surface thereon by exposing the substrate to a silicon precursor, a dopant gas and a plasma to form a doped dielectric layer, the dopant gas comprising one or more of boron atoms, or phosphorous atoms; and

annealing the doped dielectric layer for a period in a range of about 60 min to about 120 min at a temperature less than about 500 °C in a nitrogen (N_2) atmosphere to form a dielectric barrier layer.

18. The method of claim 17, further comprising exposing the dielectric barrier layer to a treatment plasma comprising ammonia to improve at least one of elasticity and hardness.

19. A method for forming a dielectric barrier layer comprising:

exposing a substrate having a copper surface thereon to a dopant gas comprising diborane to form a treated surface, the dopant gas having a flow rate in a range of about 50 sccm to about 100 sccm;

depositing a dielectric layer on the treated surface by exposing the substrate to a silicon precursor, the dopant gas and a plasma to form a doped dielectric layer;

annealing the doped dielectric layer for a period in a range of about 90 min to about 120 min at a temperature less than about 500°C in a nitrogen (N_2) atmosphere to form a dielectric barrier layer; and

exposing the dielectric barrier layer to a treatment plasma comprising ammonia.