

What is claimed is:

1. ~~A method of forming a silicon boron nitride layer, comprising:~~

~~— positioning a substrate on a pedestal in a process region within a process chamber;~~

~~heating a pedestal retaining the substrate to a deposition temperature of about 225°C to about 575°C;~~

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~~introducing a first flow of a first process gas and a second flow of a second process gas to the process region, wherein:~~

~~the first flow of the first process gas comprises:~~

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~~silane having a flow rate of about 1 sccm to about 500 sccm;~~

~~ammonia having a flow rate of about 10 sccm to about 5,000 sccm;~~

~~helium having a flow rate of about 500 sccm to about 20,000 sccm;~~

~~nitrogen (N₂) having a flow rate of about 5,000 sccm to about 25,000 sccm;~~

~~argon having a flow rate of about 50 sccm to about 10,000 sccm, and~~

~~hydrogen (H₂) having a flow rate of about 50 sccm to about 20,000 sccm, and~~

~~the second flow of the second process gas comprises:~~

~~about 2 molar percent (mol%) to about 15 mol% of diborane,~~

~~about 85 mol% to about 98 mol% of hydrogen (H₂), and~~

~~a flow rate of about 1 sccm to about 5,000 sccm;~~

~~forming a plasma concurrently with the first flow of the first process gas and the second flow of the second process gas to the process region; and~~

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~~exposing the substrate to the first process gas, the second process gas, and the plasma to deposit the silicon boron nitride layer on the substrate.~~

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2. ~~The method of claim 1, wherein the silicon boron nitride layer comprises about 40 atomic percent (at%) to about 50 at% of boron.~~

3. ~~The method of claim 1, wherein the silicon boron nitride layer has a nitrogen to silicon atomic ratio of about 1.05 to about 1.5.~~

4. ~~The method of claim 1, wherein the silicon boron nitride layer comprises about 5 at% to about 15 at% of hydrogen.~~

5. The method of claim 1, wherein the silicon boron nitride layer has a leakage current of less than 1×10^{-9} A/cm² at 1.5 MV/cm.

6. The method of claim 1, wherein the silicon boron nitride layer comprises:
about 60 at% to about 80 at% of boron bonded to silicon; and
about 20 at% to about 40 at% of boron bonded to nitrogen.

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7. The method of claim 1, wherein the first flow of the first process gas and the second flow of the second process gas are combined to produce a third flow of a third process gas prior to being introduced into the process region, and wherein the third flow of the third process gas is maintained at a temperature of about 20°C to less than 165°C.

8. The method of claim 1, wherein the first flow of the first process gas comprises:
the silane having a flow rate of about 10 sccm to about 250 sccm,
the ammonia having a flow rate of about 50 sccm to about 2,000 sccm,
the helium having a flow rate of about 750 sccm to about 15,000 sccm,
the nitrogen having a flow rate of about 10,000 sccm to about 20,000 sccm,
the argon having a flow rate of about 200 sccm to about 7,500 sccm, and
the hydrogen having a flow rate of about 200 sccm to about 15,000 sccm.

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9. The method of claim 1, wherein the second flow of the second process gas comprises:
about 3 mol% to about 12 mol% of the diborane,
about 88 mol% to about 97 mol% of the hydrogen, and
a flow rate of about 5 sccm to about 2,000 sccm.

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10. The method of claim 1, further comprising maintaining the process region at a pressure of about 2 Torr to about 8 Torr, wherein the pedestal is positioned at a process distance between the pedestal and a showerhead of the process chamber, and wherein the process distance is about 200 mil to about 1,000 mil.

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11. The method of claim 1, wherein the silicon boron nitride layer is located in a capacitor device disposed on the substrate, wherein the silicon boron nitride layer is

~~a supporter layer or a stopper layer of the capacitor device, and wherein the silicon boron nitride layer has a thickness of about 50 Å to about 800 Å.~~

12. The method of claim 1, further comprising:

~~generating the plasma in a remote plasma system disposed outside of the process chamber; and~~

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~~transferring the plasma into the process region while depositing the silicon boron nitride layer on the substrate.~~

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13. A method of forming a silicon boron nitride layer, comprising:

positioning a substrate on a pedestal in a process region within a process chamber;

introducing a first flow of a first process gas and a second flow of a second process gas to the process region, wherein:

the first flow of the first process gas comprises a silicon-containing precursor, a nitrogen-containing precursor, hydrogen (H₂), and at least two gases selected from the group consisting of argon, helium, nitrogen (N₂), and any combination thereof, and

the second flow of the second process gas comprises:

about 2 molar percent (mol%) to about 15 mol% of diborane,
about 85 mol% to about 98 mol% of hydrogen (H₂), and
a flow rate of about 1 sccm to about 5,000 sccm;

forming a plasma concurrently with the first flow of the first process gas and the second flow of the second process gas to the process region; and

exposing the substrate to the first process gas, the second process gas, and the plasma to deposit the silicon boron nitride layer on the substrate,

wherein the silicon boron nitride layer comprises about 10 atomic percent (at%) to about 50 at% of boron,

wherein the silicon boron nitride layer has a nitrogen to silicon atomic ratio of about 1.05 to about 1.5, and

wherein the silicon boron nitride layer has a leakage current of less than 1×10^{-9} A/cm² at 1.5 MV/cm.

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14. ~~The method of claim 13, and~~ wherein the silicon boron nitride layer comprises about 20 at% to about 35 at% of boron, wherein the silicon boron nitride layer has a nitrogen to silicon atomic ratio of about 1.1 to about 1.4, and wherein the silicon boron nitride layer has a leakage current of about 5×10^{-11} A/cm² to about 9.9×10^{-10} A/cm² at 1.5 MV/cm.

15. A method of forming a silicon boron nitride layer, comprising:

~~positioning a substrate on a pedestal in a process region within a process chamber;~~

~~heating a pedestal retaining the substrate to a deposition temperature of about 225°C to about 575°C;~~

~~maintaining the process region at a pressure of about 2 Torr to about 8 Torr;~~

~~introducing a first flow of a first process gas to the process region, wherein the first flow of the first process gas comprises:~~

~~silane having a flow rate of about 1 sccm to about 500 sccm,~~

~~ammonia having a flow rate of about 10 sccm to about 5,000 sccm,~~

~~helium having a flow rate of about 500 sccm to about 20,000 sccm,~~

~~nitrogen (N₂) having a flow rate of about 5,000 sccm to about 25,000 sccm,~~

~~argon having a flow rate of about 50 sccm to about 10,000 sccm, and~~

~~hydrogen (H₂) having a flow rate of about 50 sccm to about 20,000 sccm;~~

~~discontinuing the first flow of the first process gases;~~

~~forming a plasma concurrently with a second flow of a second process gas to the process region, wherein the second flow of the second process gas has a flow rate of about 1 sccm to about 5,000 sccm and comprises about 2 molar percent (mol%) to about 15 mol% of diborane and about 85 mol% to about 98 mol% of hydrogen (H₂); and~~

~~forming the silicon boron nitride layer on the substrate.~~