CLAIMS

1. A method for depositing an aluminum or gallium doped silicon nitride film in a vapor deposition method, the method comprising the steps of:

a. providing a substrate into a reactor;

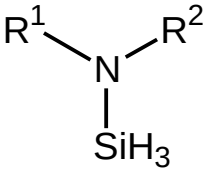
b. introducing into the reactor an metal precursor selected from the group consisting of $AlCl_3$, methylaluminum chloride, trimethylaluminum (TMA), triethylaluminum, tris(dimethylamino)aluminum (TDMAA), tris(dimethylamino)aluminum (TDMAA), tris(diethylamino)aluminum (TDEAA), gallium chloride, trimethylgallium, triethylgallium, tris(dimethylamino)gallium, tris(diethylamino)gallium, tris(ethylmethylamino)gallium, and other volatile aluminum or gallium precursors under process conditions sufficient to interact the metal precursor with the substrate;

c. purge to remove unreacted metal precursor;

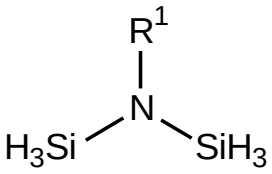
d. introducing into the reactor a plasma containing source to interact with at least a portion of the substrate and provide at least one reactive site wherein the plasma is generated at a power density ranging from about 0.01 to about 1.5 W/cm^2;

e. purging the reactor with a purge gas;

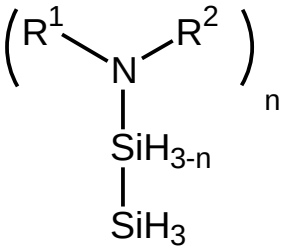
f. introducing into the reactor an aminosilane precursor represented by the following Formulae I through IV below:



I



II



III

$R^3_xSi(NR^1R^2)_yH_{4-x-y}$

IV

wherein R^1 is selected from a linear C_1 to C_{10} alkyl group, a branched C_3 to C_{10} alkyl group, a linear or branched C_3 to C_{10} alkenyl group, a linear or branched C_3 to C_{10} alkynyl group, a C_1 to C_6 dialkylamino group, an electron withdrawing group, a C_6 to C_{10} aryl group, a C_1 to C_{10} alkyl silyl group, and a silyl group; R^2 and R^3 is selected from hydrogen, a linear C_2 to C_{10} alkyl group, a branched C_3 to C_{10} alkyl group, a linear or branched C_3 to C_6 alkenyl group, a linear or branched C_3 to C_6 alkynyl group, a C_1 to C_6 dialkylamino group, a C_6 to C_{10} aryl group, an electron withdrawing group, and a C_4 to C_{10}

aryl group; n=1 or 2; x=0,1, 2; y=2, 3; and optionally wherein R^1 and R^2 in Formulae I, III and IV are linked together to form a ring selected from a substituted or unsubstituted aromatic ring or a substituted or unsubstituted aliphatic ring; R^3 is selected from a linear C_1 to C_{10} alkyl group, a branched C_3 to C_{10} alkyl group, a linear or branched C_2 to C_{10} alkenyl group, a linear or branched C_2 to C_{10} alkynyl group wherein the aminosilane precursor interacts with at least a portion of the surface of the substrate;

g. purging the reactor with a purge gas;

h. introducing the plasma containing source into the reactor to react with at least a portion of the chemisorbed layer and provide at least one reactive site wherein the plasma is generated at a power density ranging from about 0.01 to about 1.5 W/cm^2; and;

i. optionally purge the reactor with an inert gas; and wherein the steps b through i are repeated until a desired thickness of the film is obtained.

2. The method of Claim 1 wherein the at least one aminosilane precursor is at least one member selected from the group consisting of di-iso-propylaminosilane, di-sec-butylaminosilane, phenylmethylaminosilane, 2,6-dimethylpiperidinosilane, N-methylcyclohexylaminosilane, N-ethylcyclohexylaminosilane, N-isopropylcyclohexylaminosilane, 2-methylpiperidinosilane, N-silyldecahydroquinoline, 2,2,6,6-tetramethylpiperidinosilane, 2-(N-silylmethylamino)pyridine, N-t-butyldisilazane, N-t-pentyldisilazane, N-(3-methyl-2-pyridyl)disilazane, N-(2-methylphenyl)disilazane, N-(2-ethylphenyl)disilazane, N-(2,4,6-trimethylphenyl)disilazane, N-(2,6-di-iso-pripylphenyl)disilazane, di-iso-propylaminodisilane, di-iso-butylaminodisilane, di-sec-butylaminodisilane, 2,6-dimethylpiperidinosilane, N-methylcyclohexylaminodisilane, N-ethylcyclohexylaminodisilane, phenylmethylaminodisilane, 2-(N-disilylmethylamino)pyridine, N-phenylethyldisilane, N-isopropylcyclohexylaminodisilane, 1,1-(N,N'-di-tert-butylethylenediamino)disilane, bis(iso-propylamino)methylsilane, bis(iso-butylamino)methylsilane, bis(sec-butylamino)methylsilane, bis(tert-butylamino)methylsilane, bis(tert-pentylamino)methylsilane, bis(cyclohexylamino)methylsilane, bis(iso-propylamino)dimethylsilane, bis(iso-butylamino)dimethylsilane, bis(sec-butylamino)dimethylsilane, bis(tert-butylamino)dimethylsilane, bis(tert-pentylamino)dimethylsilane, and bis(cyclohexylamino)dimethylsilane, bis(dimethylamino)silane, bis(diethylamino)silane,

bis(ethylmethylamino)silane, bis(tert-butylamino)silane, tris(dimethylamino)silane, tris(iso-propylamino)silane, trisilylamine, and trisilylamine derivatives.

3. The method of claim 1 the plasma containing source is at least one member selected from the group consisting of a nitrogen and argon plasma, a nitrogen and helium plasma, an ammonia plasma, a nitrogen and ammonia plasma, an ammonia and helium plasma, an ammonia and argon plasma, a NF_3 containing plasma, an organoamine containing plasma, and mixtures thereof.

4. The method of claim 1 wherein the film has a density of about 2.0 g/cc or greater.

5. The method of claim 1 wherein the method is a vapor deposition process and is selected from the group consisting of at least one selected from plasma enhanced chemical vapor deposition and plasma enhanced cyclic chemical vapor deposition.

6. The method of Claim 1 wherein the method is conducted at one or more temperatures of about 500°C or less.

7. The method of Claim 1 wherein the method is conducted at one or more temperatures of about 400°C or less.

8. The method of claim 1 wherein the method is conducted at one or more temperatures of about 300°C or less.

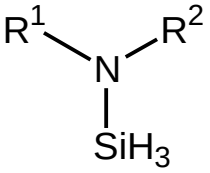
9. A method of forming an aluminum doped silicon nitride or aluminum doped silicon carbonitride or gallium doped silicon nitride or gallium doped silicon carbonitride film, the method comprising the steps of:

a. providing a substrate in a reactor;

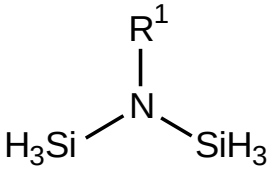
b. introducing into the reactor at least one aluminum precursor selected from the group consisting of $AlCl_3$, trimethylaluminum (TMA), triethylaluminum, methylaluminum chloride, tris(dimethylamino)aluminum (TDMAA), tris(dimethylamino)aluminum (TDMAA), tris(diethylamino)aluminum (TDEAA), gallium chloride, trimethylgallium, triethylgallium, tris(dimethylamino)gallium, tris(diethylamino)gallium, tris(ethylmethylamino)gallium, and other volatile aluminum or gallium precursors;

c. purge to remove unreacted aluminum precursor or gallium precursor;

d. introducing into the reactor an aminosilane precursor represented by the following Formulae I through IV below:



I



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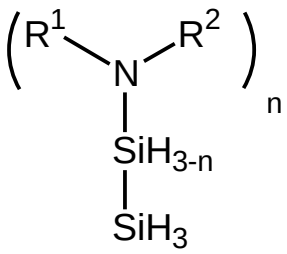

III

$R^3_xSi(NR^1R^2)_yH_{4-x-y}$

IV

wherein R^1 is selected from a linear C_1 to C_{10} alkyl group, a branched C_3 to C_{10} alkyl group, a linear or branched C_3 to C_{10} alkenyl group, a linear or branched C_3 to C_{10} alkynyl group, a C_1 to C_6 dialkylamino group, an electron withdrawing group, a C_6 to C_{10} aryl group, a C_1 to C_{10} alkyl silyl group, and a silyl group; R^2 and R^3 is selected from hydrogen, a linear C_2 to C_{10} alkyl group, a branched C_3 to C_{10} alkyl group, a linear or branched C_3 to C_6 alkenyl group, a linear or branched C_3 to C_6 alkynyl group, a C_1 to C_6 dialkylamino group, a C_6 to C_{10} aryl group, an electron withdrawing group, and a C_4 to C_{10} aryl group; n=1 or 2; x=0,1, 2; y=2, 3; and optionally wherein R^1 and R^2 in Formulae I, III and IV are linked together to form a ring selected from a substituted or unsubstituted aromatic ring or a substituted or unsubstituted aliphatic ring; R^3 is selected from a linear C_1 to C_{10} alkyl group, a branched C_3 to C_{10} alkyl group, a linear or branched C_2 to C_{10} alkenyl group, a linear or branched C_2 to C_{10} alkynyl group wherein the aminosilane precursor reacts on at least a portion of the surface of the substrate to provide a chemisorbed layer;

e. purging the reactor with a purge gas;

f. introducing a plasma containing source into the reactor to react with at least a portion of the chemisorbed layer and provide at least one reactive site wherein the plasma is generated at a power density ranging from about 0.01 to about 1.5 W/cm^2 and;

g. optionally purge the reactor with an inert gas; and wherein the steps b through g are repeated until a desired thickness of the film is obtained.

10. The method of Claim 9 wherein the at least one aminosilane precursor is selected from the group consisting of di-iso-propylaminosilane, di-sec-butylaminosilane, phenylmethylaminosilane, 2,6-dimethylpiperidinosilane, N-methylcyclohexylaminosilane, N-ethylcyclohexylaminosilane, N-isopropylcyclohexylaminosilane, 2-methylpiperidinosilane, N-silyldecahydroquinoline, 2,2,6,6-tetramethylpiperidinosilane, 2-(N-silylmethylamino)pyridine, N-t-butyldisilazane, N-t-pentyldisilazane, N-(3-methyl-2-pyridyl)disilazane, N-(2-methylphenyl)disilazane, N-(2-ethylphenyl)disilazane, N-(2,4,6-trimethylphenyl)disilazane, N-(2,6-di-iso-pripylphenyl)disilazane, di-iso-propylaminodisilane, di-iso-butylaminodisilane, di-sec-butylaminodisilane, 2,6-dimethylpiperidinosilane, N-methylcyclohexylaminodisilane, N-ethylcyclohexylaminodisilane, phenylmethylaminodisilane, 2-(N-disilylmethylamino)pyridine, N-phenylethyldisilane, N-isopropylcyclohexylaminodisilane, 1,1-(N,N'-di-tert-butylethylenediamino)disilane, bis(iso-propylamino)methylsilane, bis(iso-butylamino)methylsilane, bis(sec-butylamino)methylsilane, bis(tert-butylamino)methylsilane, bis(tert-pentylamino)methylsilane, bis(cyclohexylamino)methylsilane, bis(iso-propylamino)dimethylsilane, bis(iso-butylamino)dimethylsilane, bis(sec-butylamino)dimethylsilane, bis(tert-butylamino)dimethylsilane, bis(tert-pentylamino)dimethylsilane, and bis(cyclohexylamino)dimethylsilane, bis(dimethylamino)silane, bis(diethylamino)silane, bis(ethylmethylamino)silane, bis(tert-butylamino)silane, tris(dimethylamino)silane, tris(iso-propylamino)silane, and trisilylamine.