CLAIMS

1. A method of depositing a film, the method comprising:

exposing a substrate to a chalcogen precursor, the chalcogen precursor comprising one or more of a thiosilane, a selinosilane, and a tellurosilane and having a structure of Formula (I) $Me_nSi(MR)_{4-n}$ or Formula (II) $Si(MR)_4$, wherein n is from 3 to 1, M is selected from the group consisting of sulfur (S), selenium (Se), and tellurium (Te), and R is selected from the group consisting of Ph, Ph-(*p*-CH_3), Ph-(2,4,6-CH_3), Ph-(*p*-CF_3), and Ph-(*p*-NO_2); and

exposing the substrate to a reactant to form a silicon nitride (Si_xN_y) film on the substrate.

2. The method of claim 1, wherein the substrate is exposed to the chalcogen precursor at a temperature in a range of from 100 ºC to 550 ºC.

3. The method of claim 1, wherein the method comprises one or more of chemical vapor deposition or atomic layer deposition.

4. The method of claim 3, wherein the substrate is exposed to the chalcogen precursor and the reactant simultaneously.

5. The method of claim 3, wherein the substrate is exposed to the chalcogen precursor and the reactant sequentially.

6. The method of claim 1, further comprising purging the substrate of the chalcogen precursor prior to exposing the substrate to the reactant.

7. The method of claim 6, wherein purging comprises one or more of applying a vacuum or flowing a purge gas over the substrate.

8. The method of claim 7, wherein the purge gas comprises one or more of nitrogen (N_2), helium (He), and argon (Ar).

9. The method of claim 1, wherein the reactant comprises one or more of dimethylhydrazine (DMH), alkyl amine, hydrazine, alkyl hydrazine, allyl hydrazine, hydrogen (H_2), and ammonia (NH_3).

10. The method of claim 1, wherein the film is substantially free of halogen.

11. A method of depositing a halogen-free film, the method comprising:

forming a silicon nitride (Si_xN_y) film in a process cycle comprising sequential exposure of a substrate to a chalcogen precursor, purge gas, reactant, and purge gas, the chalcogen precursor comprising one or more of a thiosilane, a selinosilane, and a tellurosilane and a pseudohalide derivative, the pseudohalide derivative selected from the group consisting of thiocyanate, isothiocyanate, selenocyanate, and tellurocyanate.

12. The method of claim 11, wherein the reactant comprises one or more of dimethylhydrazine (DMH), alkyl amine, hydrazine, alkyl hydrazine, allyl hydrazine, hydrogen (H_2), and ammonia (NH_3).