CLAIMS

What is claimed is:

1. A method for forming a 2D transition metal disulfide and/or diselenide containing film on a substrate comprising generating one or more of H_2S and H_2Se *in situ* in a deposition chamber, wherein the forming of the 2D transition metal disulfide and/or diselenide containing film comprises one of:

(A) a chemical vapor deposition (CVD) process comprising the steps of:

(1) contacting a substrate in a deposition chamber with a vapor including

(a) one or more externally supplied metal precursor and

(b) one or more of **(i)** H_2S and **(ii)** H_2Se; and

(2) optionally purging the vapor with an inert gas, or

(B) a thermal atomic layer deposition (ALD) process or thermal ALD-like process comprising the steps of:

(1) contacting a substrate in a deposition chamber with a first vapor including one of

(a) one or more externally supplied metal precursor or

(b) one or more of **(i)** H_2S and **(ii)** H_2Se;

(2) purging the first vapor with an inert gas;

(3) contacting a second vapor including the other of

(a) the one or more externally supplied metal precursor or

(b) the one or more of **(i)** H_2S and **(ii)** H_2Se;

(4) purging the second vapor with inert gas; and

(5) sequentially repeating steps (1) through (4) until a desired thickness of the metal-containing film is obtained,

wherein

(i) the H_2S is generated *in-situ* by reacting a compound of formula $(R^1R^2R^3Si)_2S$ wherein R^1, R^2 and R^3 are each independently hydrogen, a C_1-C_6 alkyl, C_2-C_6 alkenyl, C_3-C_6 aryl, benzyl or C_2-C_6 alkynyl group + NH_3 within the deposition chamber, and

(ii) the H_2Se is generated *in-situ* by reacting a compound of formula $(R^1R^2R^3Si)_2Se$ wherein R^1, R^2 and R^3 are each independently hydrogen, a C_1-C_6 alkyl, C_2-C_6 alkenyl, C_3-C_6 aryl, benzyl or C_2-C_6 alkynyl group + NH_3 within the deposition chamber.

2. The process of claim 1, wherein one or more of R^1, R^2 and R^3 comprises a C_1-C_6 alkyl group, a branched C_3-C_6 alkyl group or a C_3-C_6 unsubstituted cyclic alkyl group.

3. The process of claim 1, wherein one or more of R^1, R^2 and R^3 comprises a C_1-C_6 alkyl group.

4. The process of claim 1, wherein one or more of R^1, R^2 and R^3 comprises a C_1-C_6 alkyl group selected from the group of a methyl group, an ethyl group, a propyl group, a butyl group, a pentyl group and a hexyl group.

5. The process of claim 1, wherein one or more of R^1, R^2 and R^3 comprises a methyl group.

6. The process of claim 1, wherein one or more of R^1, R^2 and R^3 comprises a C_2-C_6 alkenyl group selected from a linear alkenyl group and a branched alkenyl group.

7. The process of claim 1, wherein one or more of R^1, R^2 and R^3 comprises a C_2-C_6 linear alkenyl group selected from the group of ethenyl, 1-propenyl, 2-propenyl, 1-butenyl, trans-2-butenyl, cis-2-butenyl, 3-butenyl, 1-pentenyl, trans-2-pentenyl, cis-2-pentenyl, trans-3-pentenyl, cis-3-pentenyl and 4-pentenyl.

8. The process of claim 1, wherein one or more of R^1, R^2 and R^3 comprises a C_2-C_6 branched alkenyl group selected from isobutenyl, isopentenyl (2-methylbut-1-enyl, 3-methylbut-1-enyl) and isoamylenly (2-methylbut-2-enyl).

9. The process of claim 1, wherein one or more of R^1, R^2 and R^3 comprises a C_3-C_6 aryl group.

10. The process of claim 1, wherein one or more of R^1, R^2 and R^3 comprises a C_3-C_6 aryl group that is an aromatic group.

11. The process of claim 1, wherein one or more of R^1, R^2 and R^3 comprises a phenyl group.

12. The process of claim 1, wherein one or more of R^1, R^2 and R^3 comprises a benzyl group.

13. The process of claim 1, wherein one or more of R^1, R^2 and R^3 comprises a C_2-C_6 alkynyl group.

14. The process of claim 1, wherein one or more of R^1, R^2 and R^3 comprises a C_2-C_6 alkynyl group selected from the group of ethynyl, propynyl, propargyl, but-1-ynyl, but-2-ynyl and but-3-ynyl.

15. The process of claim 1, wherein **(i)** the H_2S is generated *in-situ* by reacting $TMS_2S + NH_3$ within the deposition chamber.

16. The process of claim 1, wherein **(ii)** the H_2Se is generated *in-situ* by reacting $TMS_2Se + NH_3$ within the deposition chamber.

17. The process of claim 1, wherein the NH_3 is flowed at from 50 sccm to 2000 sccm during the $(R^1R^2R^3Si)_2S$ pulse.

18. The process of claim 1, wherein the substrate temperature is from 150 °C to 650 °C.

19. The process of claim 1, wherein the metal precursor gas comprises one or more of MoO_2Cl_2, $MoCl_5$, $MoCl_6$, $MoOCl_4$, WO_2Cl_2, WCl_4, WCl_5, WCl_6, $WOCl_4$, $TiCl_4$, $ZrCl_4$, $HfCl_4$, $TaCl_4$, $TaCl_5$, $NbCl_4$, $NbCl_5$ and combinations thereof.

20. The process of claim 1, wherein the metal precursor comprises one or more of MoBURE (Bis(t-butylimido)bis(dimethylamino)molybdenum(VI)), TDMAMo, TDEAMo, TEMAMo, WNBURE (Bis(t-butylimido)bis(dimethylamino)tungsten(VI)), TEMAZ, TEMAHf, TEMAT, TDMAT, TDEAT and combinations thereof.